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Forthcoming Events.

JUNE 21.

Royal Statistical Society:—Mr. D. Caradog Jones, of the School of Social Science, University of Liverpool, will read a Paper on "Pre-War and Post-War Taxation."

JUNE 22.

Institution of Welding Engineers:—Ordinary meeting in London. "The Red-Shortness of Weld Metal," Paper by A. H. Goodger, M.Sc. Tech.A.I.C.

JULY 4 to 9.

Society of Chemical Industry:—Forty-sixth annual meeting to be held in Edinburgh.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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The Consumer's Point of View.

One of the most interesting developments noticed in the advertising world during the past two years has been the marked tendency towards group advertising, in order to impress on the public the merits of a particular material. So far as the general public is concerned, everyone has noticed this in the case of gas, electricity, the telephone, plate-glass, fruit and vegetable produce, and a number of others. There are, however, other cases where the purchasing public consists of a small and limited group of officially-constituted buyers, whose attitude towards buying is necessarily somewhat different from that of the general public. Nevertheless, group advertising has been employed successfully in extending the markets for such products as brick, concrete, wrought iron, etc., not ordinarily bought by the general public. It also appears to have been tried, to a limited extent, for cast-iron hollow-ware. The brass and copper trades have an "Extended Uses Council," as a result of whose activities the trades in question have in some measure found substitutes for the lost munitions market.

There has, however, been no marked tendency to treat cast iron in the same way. We may assume that the manufacturers of the products enumerated above have faith in their material and confidence that its uses can be extended, and that they are to that end prepared to incur considerable expense. Is cast iron always to be a material doomed to be displaced by these others? The history of cast iron has been one of almost continual replacement by other materials, so that the increased demand that would normally accrue by means of increasing population is in large measure offset by the encroachments of other materials.

It is often said by way of excuse that the engineer—the great user of cast iron—will not pay more for an improved product. This we believe to be thoroughly fallacious. Engineering development reveals continuous attempts to find materials capable of meeting the ever-increasing demands placed upon them. Invariably, the new material is more expensive than the old, often to a very considerable degree. Provided that an improvement in cast iron can be made sufficiently regular to be guaranteed, and provided, of course, that the cost is not so far increased as to make steel or non-ferrous metals practicable as alternatives, we are confident that the engineer will be perfectly prepared to pay for improvements.

The fallacy is just as great when the point of view of a less sophisticated type of buyer is considered. Many cast-iron products, notably in the hollow-ware and light castings sections, go more or less directly to the general public, and it is impossible to dispute the growing preference for stamped and pressed ware, and for such non-ferrous materials as aluminium and nickel—this, although such usually cost considerably more.

The founder appears, therefore, to need an entirely new outlook on his problem; he needs faith in his material and confidence in its future. Above all, the market for cast iron can only be stabilised and extended by some form of concerted action among the makers. At the present time there are far too many foundries with idle and rapidly depreciating equipment, and some action is needed which will produce a state of affairs we all desire to see, in which every foundry is normally well employed.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Holley Moulding Process.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In the discussion of Prof. Hinchley's Paper to the Chemical Engineers, Mr. J. E. Fletcher states as follows:—

"A great deal of time had been devoted to experiment before the exact composition of the metal to be used had been arrived at. It was not metal which we in this country would call high class, and if it were not for the fact that it was poured into metal moulds and cooled quickly, the castings would be unsound and coarse grained."

The fact is that until recently we were making the Fordson tractor vapouriser in sand moulds with exactly the same metal with which we were pouring the metal moulds. The iron used is not an exceptional iron in this neighbourhood, consisting as it does of 50 per cent. No. 1 pig and 50 per cent. first-class automobile scrap. The experimental work has been directed not to finding a special composition iron which would produce satisfactory results, but to obtain a process and machines which would satisfactorily use the available metal in the Detroit area, which, of course, is the metal available generally throughout the United States.

With regard to Mr. Tungay's statement that the iron was only applicable to the production of small castings, the fact that we have made many thousands of Fordson exhaust manifolds weighing 22 lbs. is sufficient answer to this. The saving in this particular casting was 33 per cent.

Yours, etc.,
HOLLY CARBURETOR COMPANY.
S. M. UDALE.

Holly Carburetor Company,
Vancouver Avenue,
Detroit, Michigan.
May 26, 1927.

Combustibility of Coke.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I was most interested in reading Mr. W. Diamond's Paper published in the May 26 edition of the JOURNAL on "The Combustibility of Coke." It is not often that a Paper is delivered treating with a subject of such import to the foundry trade, and I am sure Mr. Diamond should be commended on this Paper. However, there are one or two points open to constructive criticism worthy of further attention.

In the first place I am in complete agreement with the specification outlined, especially regarding coke having a good cellular structure. From experimental work done in this country and in Germany, it would seem that this cellular structure bears a very strong relationship to the combustibility of coke when used in the cupola for melting iron, and it would have been of great interest to have had definite data illustrating this point, especially as a comparison between by-product and beehive coke. Personal work done some time ago pointed to beehive coke being the most satisfactory fuel for efficient cupola melting, and these results are not in agreement with Mr. Diamond's contentions. Experiments were done in the laboratory, and also extensive trial runs of the two brands of coke put through the cupola. In every instance best melting was obtained, together with highest superheated iron, when a certain cellular structured beehive coke was used, and this coke was neither dense nor hard. The following figures give some comparisons between the beehive and by-product cokes used:—

	Durham beehive.	Durham by-product.
Porosity	50.15	37.55
Weight per cub. ft. ..	62.21 lbs.	77.94 lbs.
Fixed carbon	88.98%	87.85%
Volatiles	1.40%	1.67%
Ash	8.5%	8.8%
Moisture	.27%	.95%
Sulphur	.85%	.73%

A polished surface is not representative of beehive coke on the whole, whilst in by-product coke the silvery lustre is non-existent. The dulness on this latter coke arises from the separation of carbon from the products of distillation which are very high in carbon. This deposit will tend to fill up the pores composing the cellular structure, and it would seem that Mr. Diamond's comparison between these two brands of coke should be reversed.

I would also like to suggest to Mr. Diamond that the most suitable coke for melting pig-iron and scrap will be that which can produce a high temperature for melting purposes in a specified time, readily combining with the delivered air, or in other words, it is advantageous to have an easily combustible coke, this combustibility depending on the chemical analysis of the coke, together with the surface cellular structure. Of course, I do not intend these remarks to be in favour of all brands of beehive coke, but are representative of conditions as found in Durham in 1924.—Yours, etc.,

F. HUDSON,
Works Chemist.
Glenfield & Kennedy, Limited.
Kilmarnock, June 3, 1927.

Progress in Ironfounding.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Under above heading Mr. Shaw's letter in last week's issue was interesting because he said much about the perlit process. Although having no connection with the British Perlit Iron Company, somewhat naturally I am delighted to observe results—both from practice and from research—accumulating to prove that my knowledge was not astray when it told me that the perlit process was an advance upon anything we had done before.

My friend, Mr. Shaw, is not yet *au fait* with the process. He says: "*I saw a set of micros cut from similar castings . . . one Lanz and the other ordinary dry-sand with controlled composition . . . no difference could be found in the structure.*" This is no test, and any old piece of stove-grate iron might give all-pearlitic micros.

Mr. Shaw also writes: "*I have written the above, not to detract from the excellent work done by Herr Sipp, but to show that equal results are possible in another way.*" Argument is useless here, and I will put the case as follows:—Let me issue a specification for a perlit casting and let Mr. Shaw meet that specification by a casting produced without the aid of the perlit process. I have an open mind on the point, and am watching all new irons with the greatest interest. Alloy additions, for instance, are in the right direction, but they have not come yet, and I predict they will be more useful to perlit licensees than to others.

Mr. Shaw says: "*It is hardly possible to apply the perlit process to certain castings because of their bulk and shape.*" I can recall when people said it could not be applied at all. Had I the job of making turbine castings having those properties which, as I believe, are obtainable only by perlit means, I would do it.

At this point Mr. Shaw is humorous, for he says: "*The only course, then, is to raise the silicon and obtain the pearlitic structure by composition alone.*" This means that he would make his turbine castings precisely as I have made them ever since I made any . . . but they had not the properties of perlit.

The proof is, as it always has been, not in statements or separate test bars but in castings. Let Mr. Shaw or anyone meet a perlit specification and then I shall know that there are two ways of producing perlit properties; up to the present I know of one way only.

Yours, etc.,
HORACE J. YOUNG, F.I.C.
3, Central Buildings, Westminster, London, S.W.1.
June 10, 1927.

A MEETING of the debenture holders of Robert Heath and Low Moor, Limited, has been called, at which the directors will submit a proposal for the suspension of interest and sinking fund until the end of 1930.

Absorbed Gases in Iron and the Creation of Gas-Holes in Castings.*

By Ben Hird.

Blow-holes and cavities in castings are a nightmare to all foundry men. Much thought and experiment have been given to these troubles, and a number of good essays have been read. Sound theories have been expounded and discussed. It is generally agreed that these troubles do not arise from any one source. The expansion of the mould during—or just prior to solidification (described by the late Mr. Robert Buchanan in his Paper on "Liquid Contraction" and now known as the "Box Effect") plays its part.

Mr. John Longden in a lecture given before the Scottish Branch made experiments proving this, and, also, that a certain amount of liquid shrinkage takes place during solidification. He states, as the result of his investigations that "in all sand-made castings the voids left are the combined resultants of two factors 'shell expansion' and net liquid shrinkage." He rather discounts the possibility of gases causing any of these troubles and remarks "that the advocates of this view should inform us what has become of the metal which presumably occupied the space, afterwards occupied by the gas." In the author's opinion, at times, the gas enters and expands in the voids primarily caused by shell expansion and liquid shrinkage, just as some of these voids are filled with free graphite and called spongy places, having the appearance of dark patches, more or less solid. Others have distinct cavities in which the fir-tree like iron carbide crystals have had freedom to grow. To classify these defects under two heads:—(a) Shell expansion and net liquid shrinkage only and (b) directly caused, or due to gases:

(a) Would include concave distortions of the casting skin, spongy places filled with free graphite, rough crystalline cavities with fir-tree crystals and very open porous structure of the grain, whilst (b) would cover all smooth-skinned cavities, correctly termed blow-holes and gas-holes, caused by vapours, including air, formed in the casting by various causes. To enumerate a few, gases given off by small particles of slag carried into the mould by the metal; bubbles of air carried into the mould by the pouring stream; steam generated from moisture in the mould; liberation after pouring of gases occluded in the metal; gas given off by the sand and other bodies in the mould just before and during solidification.

The errors giving rise to some of these defects and others have been ably dealt with by Mr. E. Longden in his Papers on "An Analysis of Defective Castings," also "Importance of Venting." It is obvious that in the two classifications (a) and (b) the causes are distinct one from the other. Although they exercise an influence upon each other, as, when the cavity formed in the casting is a direct result of liquid shrinkage and *no* gases are present in the vicinity, a partial vacuum is created, in which the free graphite can form, or the iron-carbide crystals grow. Should a gas be present or generated in or near the cavity, it expands to its maximum (limited by the resistance of the surrounding crystals) and forms a smooth-skinned hole into which neither graphite, or iron carbide crystals can grow owing to the pressure of the gas.

It is sometimes found that small pellets of iron phosphide are squeezed into these gas-holes by the pressure of the contracting mass of metal. They seldom entirely fill the cavity and always have a smooth fine skin due to the presence and pressure of gas.

Apart from blown castings of the violent type, when there is no question of where the metal has gone, gases from various sources cause cavities, without giving any indication of their presence. They are often well hidden under the skin and cannot be discovered during dressing though some are found by the machinist, but in the most part they remain for ever hidden. When gases are given off from chills and other fairly large metal inclusion in the mould, the liquid metal will come up and overflow the risers in a very stealthy manner, usually some four to five minutes after pouring, when the ladle has gone away and the moulder commenced to feed. It is then a hopeless case, for the runners are set, and no method is known for persuading the metal to return.

It was distressing circumstances such as these, that forced the author to the conclusion that metals contain a large amount of occluded gases, which are given off when their temperature is raised above a certain point. Until recently he has never been able actually to prove this, in spite of many indications of its presence. Consider a few of the most common metal insertions into moulds, such as sprigs, studs, chaplets. Most foundrymen have experienced trouble with small blow-holes in the immediate vicinity of these. Usually they are put down to the presence of moisture or rust, but this is seldom the cause, for the trouble often

FIG. 1.

occurs in thick sections, where the metal would remain fluid enough to allow any steam generated from moisture to pass through it, for this action would take place the instant the molten metal touched it. Now the stud, or nails, must be raised to a certain temperature before the gas is given off. This action absorbs the heat from the surrounding metal, and iron carbide crystals begin to form, creating a kind of envelope of plastic metal, intermixed with the still fluid iron-phosphide. The liberated gases expanding, push their way along the liquid passages until they reach the molten metal, when they expand to the limit of the resistance of the metal. The following experiments were carried out with sprigs, pipe nails and studs:—

1. Open sand moulds, 2½ in. × 2½ in. × 6 in. long, were prepared in which were placed:—(a) Three new tinned studs 1½ in. long × 1¼ in. diameter heads. These, when broken, showed that one was badly blown, and two were solid: (b) three pipe nails 5½ in. long, ⅞-in. heads, which when broken proved that all three were badly blown: and (c) three new 6-in. sprigs, which were *all blown*.

2. Open sand moulds, 2½ in. × 1¼ in. × 6 in. long, were prepared, and in these were placed (d) three studs, as in experiment (a) and resulted in two being solid and one blown; (e) three pipe nails, as in experiment (b) which were all blown: and (f) Three 6-in. sprigs, as in experiment (f) and again all were blown.

3. In this case the open sand moulds were 2½ in. × ¾-in. × 6 in. long, and in these were placed (g) three pipe nails, as in experiment (a) and all were blown: (h) three 6-in. sprigs, as in experiment (b), but cast dry, and again all were blown: and (h1) three 6-in. sprigs, as in experiment (b), but dipped in water just before casting. Once more all were blown. There was, however,

* A Paper read before the Lancashire Branch of the Institute of British Foundrymen, Mr. J. S. G. Primrose, presiding.

no disturbance when the molten metal touched the damp sprig during pouring.

4. In open sand moulds 2½ in. × ½ in. × 6 in. long, there were placed (i) three 6-in. sprigs, as in experiment (a), but dry, and cast with *hot* metal, and they were all blown; (a) experiment I repeated, but cast with *dull* metal. This resulted in two being sound and one blown; (b) experiment I repeated with wet sprigs, but cast with *hot* metal and again all were blown; (j) experiment I repeated, but the sprigs were dipped in water and cast while wet with *dull* metal. This gave two solid and one blown casting.

5. An open sand mould 2½ in × ¾ in. × 6 in. long was prepared, and in it was placed (k) Esso Chaplets. The mould was cast *hot* and was quite solid.

A desire to prove the existence of these gases and their composition as far as possible, with the apparatus available, led me to make the experiments described under the title of "Gases Evolved from Heated Iron," and published in THE FOUNDRY TRADE JOURNAL, March 18, 1926, p. 219. The method adopted in these experiments was based on improved results obtained by using round chills with a vent hole in the centre, as compared with solid chills. If gases came away *via* the vent hole, then it would not be very difficult to collect them. The first experiment was made with a piece of wrought-iron pipe, as being the most likely to

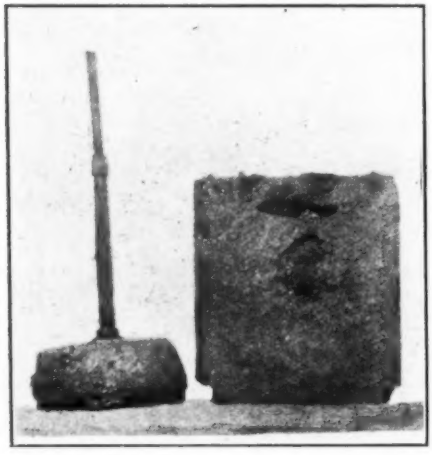


FIG. 2.

be successful, having a thin section and large diameter hole through which the gases could escape and be collected as described in the reference quoted above.

Further experiments on the same lines were made in an endeavour to discover an explanation of the distortion to the solid chills. The chills were all cast from the same ladle of iron. When finished off and ready for use they were carefully weighed. Three moulds were made, one mould being 8 in. diameter and two of 10 in. diameter, whilst all were 10 in. long. The same procedure as before was followed; the bottles were connected up before pouring the moulds.

The mould of 8 in. diameter cast with dull metal resulted in the gas coming into the bottle rapidly as soon as the mould was filled; in appearance it was like thick, heavy tobacco smoke. The 500-c.c. bottle was filled in five minutes, a second bottle filled in seven minutes, and the third bottle in eight minutes, making a total of 1,500 c.c. of gas in 20 minutes. The gas in the second and third bottles was white and misty, but not so dense as No. 1; in all three bottles the gas cleared and became transparent after standing for 20 to 30 minutes. When this casting was broken it was perfectly solid. The hole formed by the chill was sound and true, the chill showed no signs of distortion, and only lost 5 grams in weight (first weighing 3,191.6 grams and the second 3,186.6 grams). This result is different from any other experiments made with solid chills. In the author's opinion it is due to the low temperature of the iron poured into the mould.

First 10-in. Diameter Mould.—Being poured with *very hot* iron, the gas came immediately the mould was filled, colour being a distinct white and visible, but not so heavy and smoky as previous test. For collection, a 3,000-c.c. bottle was used. Five minutes after pouring 400 c.c. collected; 10 minutes, 800 c.c. At this point an unfortunate accident happened; the gas tube of the bottle was broken, and the gas test spoilt. About five minutes after pouring, when the top of the casting was just skinned over, some liquid metal began to ooze through and flow along the top; when broken off afterwards and weighed it amounted to 1,473 grams (3 lbs. 4 ozs.) An analysis for phosphorus gave a content of 0.976 per cent. A phosphorus analysis taken from the body of the casting gave 0.847 per cent. Therefore this iron must have come from the still liquid part of the casting, and contained the usual constituents.

When this casting was broken (Fig. 1) there was a large cavity extending round two-thirds of the top, about ½ in. below the face. The displacement of the metal which had been pushed out had obviously been caused by gas which had come from the chill or the mould. In one portion of the casting gas tracks can be clearly seen running at right-angles from the chill, but only in the centre portion, between the chilling effect and the outside skin of the mould. This would appear to confirm the theory that iron-carbide crystals begin to form instantly the molten metal touches the chill or the cold sand of the mould face, the iron phosphide being still liquid allows the gases to find a passage

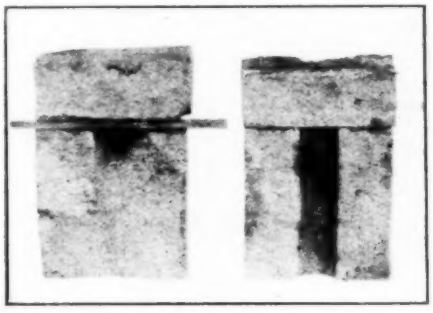


FIG. 3.

to the more liquid parts of the mould. Here there is less resistance, and they expand to the maximum of that resistance, compressing the liquid metal, or forcing it out through runners and risers, if these are not completely set. This chill was very much distorted, but the hole formed by the chill was perfectly true and smooth. The skin of the chill had a very peculiar appearance; it appears to have retained its original contour, but from inside the skin some of the original metal had disappeared, and allowed the skin to collapse and crease. A small piece of skin can be seen adhering to the side of the hole. The weight of this chill before using was 3,141.6 grams; after use, 2,991.6 grams—a loss of 150 grams. What has become of the metal? Obviously it cannot all have disappeared as a gas; that amount would fill a large gasometer, therefore it must be the metal itself that has vanished. The most feasible explanation is that the chill rapidly absorbs the heat from the surrounding molten metal and becomes semi-liquid. It is safe to assume the chill will be brought up to a temperature of at least 1,000 deg. C. Mr. J. E. Fletcher, in a lecture on "Surface and Internal Defects in Iron Castings," given before the Sheffield Branch, gives the approximate melting points of the compounds in ordinary cast iron as:—Silico-ferrite, 1,400 to 1,450 deg. C.; iron-manganese-carbon eutectic, 1,136 deg. C.; sulphide of iron, 1,250 deg. C.; sulphide of manganese, 1,500 deg. C.; carbon-iron-phosphorus eutectic, 950 deg. C.

Therefore the phosphorus eutectic in the chill would be liquid at 1,000 deg. C. The considerable pressure of the gas generated in the chill would tend to drive the eutectic along any path offering least resistance. It is possible this path may be through the skin of the chill, and the abutting

face of the hole into the passages made previously by the escaping gas, and so into the liquid part of the mould. Close examination of broken pieces of the casting reveals a number of small holes passing from the face of the chilled hole towards cavities in the centre. To check this theory, drillings were taken for comparison from the distorted part of the chill, and from the top which was out of contact with the molten metal; also from the face of the hole formed by the chill, opposite the distortion, and a part of the casting away from the influence of the chill.

Tests were taken for the phosphorus content with the following results:—From the distorted part of chill, 1.039 per cent.; from the top part of chill, 1.215 per cent.; from hole in casting opposite distortion, 0.854 per cent.; from body of casting, 0.847 per cent. The loss of phosphorus from the distorted part of the chill confirms the theory put forward. The difference in the casting is not so marked, but a lower phosphorus content would be expected in the portion adjacent to the chill, because the rapid formation of primary crystals would tend to force the phosphorus eutectic towards the liquid centre.

Second 10-in. Diameter Mould.—This was cast with hot iron, and a 3,000-c.c. collecting bottle was used. The gas began to flow immediately the mould was filled, and could be discerned passing up the glass tube in bubbles of regular size, faintly white at first becoming transparent about five minutes after commencing. The flow of gas from this casting was slower than the previous ones. About 200 c.c. collected in five minutes; afterwards gas come slowly but regularly, 600 c.c. having collected in the first hour. Being finishing time for the day, it was decided to leave the bottle connected up. The 3,000-c.c. bottle was quite full of gas when examined the following morning.

This casting, when broken, revealed that the chill had broken off close to the reducing piece and floated away to the side of the mould. A large cavity, presumably caused by gas, had formed close to the broken piece remaining in the socket. It seems safe to assume that most of the gas came from the casting. The chill was not distorted like the previous ones, but the bottom end was flattened where it had come into contact with the side of the mould. The condition of the chill in this casting tends to prove the theory that the chill reaches a semi-molten state very soon after the mould is filled. This temperature will vary in direct relation to the temperature of the metal poured into the mould; also to the size and weight of the chill, in comparison to the size of the mould, thus accounting for the variation of the distortion of the chills, and to some extent the amount of gas given off.

The analysis of these gases gave the following results:—CO_2 4.8; O_2, 5.2; CO, 10.2 per cent.; and H, nil.

The last experiment suggested a method of collecting the gas from the molten metal in the mould itself (Fig. 2). The bottom part of an old crucible was cut off, so that it formed a dish about 2½ in. deep. This was thoroughly cleaned, all trace of slag and metal removed. A hole was drilled in the centre at the bottom, and a piece of iron tube fitted in, so that it did not project into the dish, and could not come into contact with the metal. A 10-in. diameter mould was made, and the dish fixed over the top, held in the same manner as the chills. The mould was filled with hot iron until it covered the rim of the inverted dish to a depth of 1 in., making a perfect seal, and allowing about 1½ in. of dish for collection of gases, which would then pass up through the tube to the 3,000-c.c. collecting bottle. After the mould was filled, half a minute was allowed for any air in the basin or tubes to escape. When the bottle was connected up the gas rushed in at a rapid rate, filling the 3,000-c.c. bottle in six minutes. This gas also had a white, misty appearance, which cleared after standing half an hour or so. The analysis was as follows:—CO_2, 3.0; O_2, 2.0; CO, 22 per cent.; and H was present, but the amount was lost owing to explosion bursting the tube.

When this casting was broken open two types of cavities were revealed, the lower one containing dark amorphous graphite and coarse iron-carbide crystals; the top cavity a distinct gas hole, with a passage leading to the piece of old crucible used as collector.

Another experiment was made on similar lines to those carried out by Mr. J. Longden to discover the volume difference shown by weight of two castings, one cast with a 2-in. dia. sand core, the other with a 2-in. dia. cast-iron chill, having a ¾-in. dia. hole in the centre to allow the gases to escape. Two dry sand moulds were made 8 in. by 8 in. long. Care was taken to ram them solid and even, and avoid any distortion by rapping. The same arrangement of runners as described by Mr. Longden was adopted. Both were poured out of the same ladle with hot iron, and in each case about 10 lbs. of metal run through the mould.

Both castings were carefully cleaned up (Fig. 3). No difference in diameter could be found by calipering, but there was a distinct difference in the appearance of the top face. The one with the sand centre core, except at the very outer edge, showed an even depression of ⅛ in. all over the top face.

The one with the 2-in. dia. chill in the centre was almost level, with the exception of a 5/32-in. depression opposite the flow-off gate. The top face was *not* perfectly smooth; apparently the casting had sunk about 1/16 in., and some of the phosphorus eutectic had been forced out into the space, forming a thin skin of metal, which was easily chipped away.

The two castings were balanced against each other on a pair of scales. The one with the chill weighed 16 ozs. heavier. When weighed separately the respective weights were:—Casting with chill, weight after chill removed, 89½ lbs.; casting with sand core, weight after core removed, 88½ lbs. When the castings were broken, the one with the sand core showed a spongy place near the sand core in the centre. The one with the chill was perfectly solid, and showed a fine, close grain in the centre, due to the densening effect of the chill.

Conclusions.

As a result of these experiments and past experience the following conclusions are arrived at:—

(1) Sprigs, chaplets, studs, etc., are always a source of danger, especially in machined faces and where resistance to pressure is required. Their contact with the molten metal in the mould should be avoided wherever possible.

(2) When chills, or metal inserts of any kind, are used in moulds in contact with the molten metal, vent holes should be put in them to allow the gases to escape.

(3) Where chills are brought up to a high temperature in the mould they should be renewed at frequent intervals, usually after using five or six times.

(4) Moulds having metal inserts should be poured with metal as dull as is consistent with the type of casting.

(5) The amount of gas given off by chills, etc., is largely influenced by the temperature to which they are raised by the molten metal in the mould, before solidification takes place.

(6) All cast metals give off gases when liquid and during solidification until they reach a point well below dull red.

Sheffield Convention, July 5 to 8, 1927.

Members of the Institute of British Foundrymen who intend to take part in the Annual Convention, to be held at Sheffield from July 5 to 8, are reminded that their reply forms should be immediately forwarded to the General Secretary, at St. John's Street Chambers, Deansgate, Manchester.

Any members of the Institute who have not received a circular giving details of the Convention and also a reply form should immediately communicate with the General Secretary at the above address.

MESSRS. MAURICE WARLOW & COMPANY, of 12, Victoria Street, London, S.W.1, have recently been appointed by the Demag Company, of Duisburg, as sole British agents for the sale of their air compressors and blowers of all types and sizes.

D

Composition of Materials from Various Elevations in the Blast Furnace.

The United States Bureau of Mines recently completed an investigation of the gas composition, temperature, and pressure at a series of planes in a blast furnace making foundry iron in the Southern district. Samples of coke, metal, slag, limestone, and stock were obtained from points between the tuyère plane and stock line. The results of these experiments are given in Technical Paper 397 by MR. S. P. KINNEY, and recently issued by the Bureau.

The furnace was running on southern red and brown ores, and nodules made from pyrite sinter. Fig. 1 is a section of the furnace indicating the positions of the various sampling planes.

Samples of stock were collected from the interior of the furnace by opening the sample hole and allowing the stock to be blown out of the furnace into a metal container; these samples were allowed to cool in an air-tight metal container in a reducing atmosphere. Samples from Plane 5, which is 27 in. above the centre line of the tuyères, were collected by allowing the fused material to blow or run out of the furnace into the container. A number of samples were collected from the centre of the furnace at the tuyère level by drilling gas-sampling tubes which had been plugged while in the furnace. The position of the end of the sampling tube when plugged was noted.

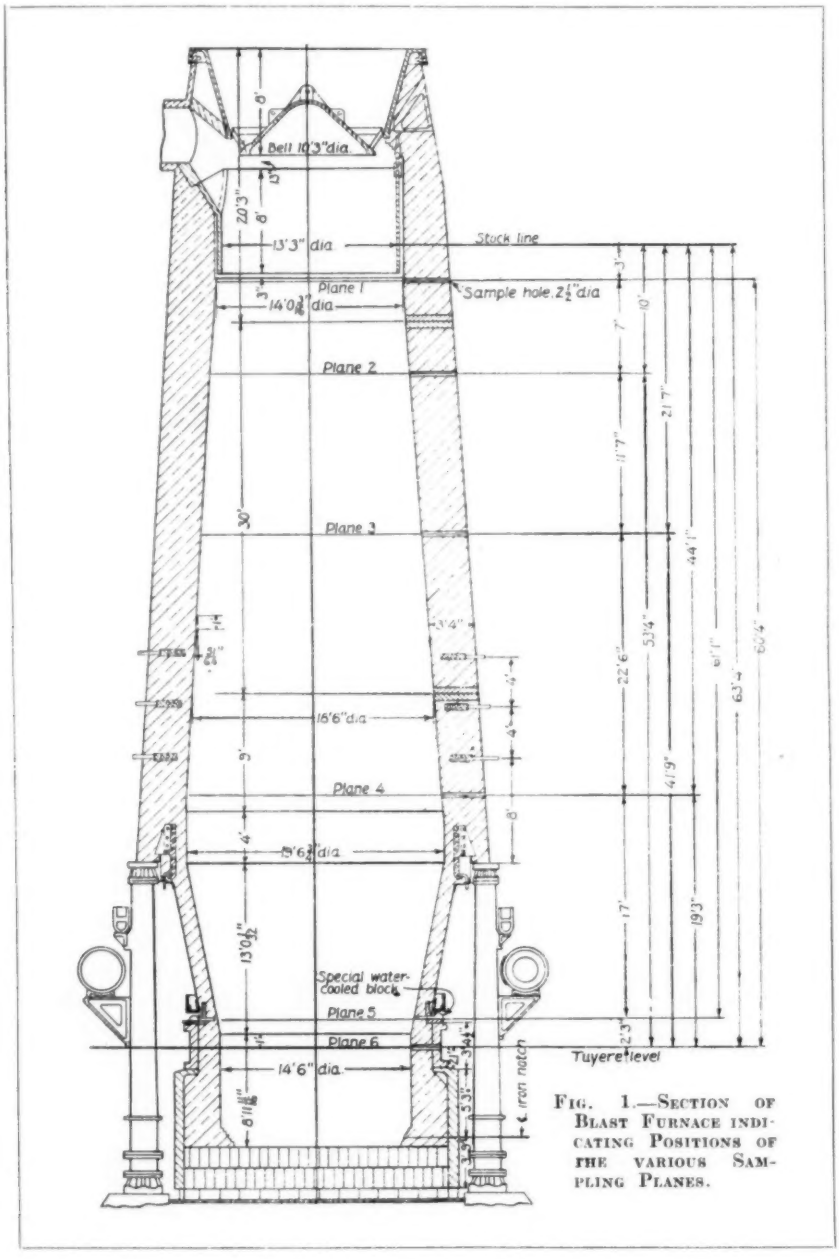


FIG. 1.—SECTION OF BLAST FURNACE INDICATING POSITIONS OF THE VARIOUS SAMPLING PLANES.

Plane 4 is near the zone of slag formation and just below the sponge-line zone. Slag is generally found here, depending on the working condition of the furnace. At this point none of the ore could be identified; reduction was nearing completion before the ore had reached this level, as gas analyses showed. Metal was found intermingled with the various materials in the samples as sponge and small pellets. As would be expected, coke was the only substance that had not changed its identity materially by the time

it had reached this plane. Samples of coke were decidedly rounded on the edges, showed signs of abrasion, and contained slightly more metallic iron than the stock coke. Some pieces were covered with semi-used slag-forming material. Several samples of thoroughly calcined limestone were obtained. Very few large pieces of limestone were found, these not over 10 mm. diameter, indicating that after calcination the limestone is thoroughly broken into finely-divided pieces and mixed with the charge. Much of the material could not be identified as ore, coke or limestone, and analysis showed these samples to be a mixture of the three. All the samples but coke taken from Plane 5 were fused. Slag samples contained metal in small pellets, which had impregnated the slag. The slag was not like that taken from the slag notch or that found at the tuyère level. It was fluffy, had an apparent density of less than 1, and was grey to white in colour.

About 1,000 gas samples were taken to determine the gas composition at various planes. Table 1 shows the temperature, pressure, and

The silica in the coke ash has little effect on the resultant amount of silicon entering the metal. The coke does not release its silica until combustion occurs in the relatively small zone of combustion at the nose of each tuyère. Before the metal reaches this level it has taken up the greater part of the silicon it will acquire, but the temperature of the combustion zone probably assists the last traces of silicon to enter the metal. There is no reason, however, to believe that the small amount of silicon taken up at the tuyère level is selected from the silicon in the coke ash in preference to that from other sources.

Manganese oxide is reduced in the presence of carbon at 1,105 deg. C.; ferro-manganese forms at 1,030 deg. C. Manganese will enter the metal in the zone of fusion, but actual samples show that a small amount of manganese has entered the metal at Plane 4. Analyses show that the average manganese content of the metal from 15 casts was 0.53 per cent. and that the metal samples taken from Planes 4 and 5 contained 0.22 per cent. and 1.10 per cent. respectively. Approximately one-third of the manganese had entered

TABLE I.—*Position of Planes, Temperatures, and Pressures and Analyses of Gases by Weight and Volume, compared with Bosh Gas and Air.**

Planes.	Above tuyère.†	Below stock line.	Pressure. lbs. per sq. in.	Temperature, deg.C.	Gas analyses.							
					Per cent. by volume.				Per cent. by weight.			
					CO†	CO	H†	N†	CO†	CO	H†	N†
	Ft. in.	Ft. in.										
Top gas ..	—	—	—	168.0	9.9	28.1	2.0	60.0	14.9	27.0	0.1	58.0
No. 1 ..	60 4	3 0	0.45	204.4	10.30	27.04	1.87	60.79	15.5	25.9	0.1	58.5
No. 2 ..	53 4	10 0	2.3	465.5‡	12.14	26.50	1.69	59.67	18.1	25.1	0.1	56.7
No. 3 ..	41 9	21 7	3.7	745.0‡	9.02	28.62	1.64	60.72	13.7	27.6	0.1	58.6
No. 4 ..	19 3	44 1	10.4	853.0‡	1.10	33.6	0.8	64.50	1.73	33.5	0.06	64.65
Bosh gas	—	—	—	1,350§	0.0	34.10	0.79	65.11	—	34.16	0.05	65.79
Air ..	—	—	—	513.8	0.0	0.0	20.9	79.08	—	—	23.15	76.85

* Composition of gases at each plane derived by integration of average analyses of a series of samples taken between inwall and centre of furnace. † Distance from centre line of tuyères. ‡ Average temperature between inwall and centre of furnace. § Assuming average temperature of Plane 5 as 1,350 deg.C.

average gas composition at each plane: the last was determined by integration of the results of gas-sampling across each plane.

The results of gas-sampling at the various planes show that 6 per cent. of the work of reduction was complete at Plane 1, 18.9 per cent. at Plane 3, and 80.5 per cent. at Plane 4; it was assumed that the process was complete at the tuyère plane. Stock sampling at Plane 4 indicated that 86.6 per cent. of the iron in the burden is in the metallic form, 4.5 per cent. as FeO, and 8.9 per cent. as Fe_2O_3. Gas-sampling indicates that 80.5 per cent. of the iron in the burden is in the metallic form; stock sampling shows 86.6 per cent. at Plane 4. If both results are considered, 80 to 85 per cent. of the iron in the burden has been reduced from the oxide state to metallic iron and is disseminated throughout the gangue material as sponge or small metallic particles. This fact might be of interest to those who are working on problems of ore beneficiation.

Silicon.

Silicon is reduced by carbon in the electric furnace at 1,460 deg. C. in the presence of iron; ferro-silicon is formed at about 1,200 deg. C. From this, it is logical to believe that, as the temperature of Plane 4 was 853 deg. C. and that of Plane 5, 1,350 deg. C., the metal would take up a considerable part of its silicon in the cast by the time it had reached Plane 5. Figures show that the average silicon content of the metal as cast was 2.92 per cent. and at Plane 5, 2.55 per cent. The metal had taken up 87.4 per cent. of its silicon by the time it reached this point in the furnace. At the tuyère plane the metal had acquired an additional 11 per cent. silicon. The data shows that most of the silicon enters the metal in the bosh of the furnace. As the temperature required to reduce silicon is higher than that required to reduce other oxides it would be expected that the silicon would enter the metal in the lower part at the bosh of the furnace rather than higher up. It is probably correctly assumed that the silicon content of the metal depends upon the temperature maintained in the furnace. High temperature is the first prerequisite for obtaining high silicon.

the metal while it was in the sponge-iron zone. While the metal was in the bosh of the furnace, travelling from Plane 4 to Plane 5, it took up 1.10 per cent., about twice the quantity found in the metal samples obtained from cast. It must be pointed out that those samples were taken at Plane 5 just above the tuyère level. On comparing these results with those of metal samples taken at cast it would appear that considerable manganese had been oxidised while the metal was passing through the tuyère zone. This finding is rather unexpected inasmuch as Bessemer, open-hearth, and electric-furnace reactions prove that silicon is oxidised preferentially or along with the manganese. Here manganese is reduced by half, while silicon is gaining 12 per cent. The fact that the metal loses considerable sulphur at the same time indicates that the manganese may be lost as manganese sulphide.

Phosphorus.

Phosphorus charged with the raw material generally enters the metal, and it would be desirable to eliminate it, but so far this is not practicable. It is generally conceded that all of the phosphorus entering the furnace finds its way to the metal, unless the furnace is working abnormally. Careful examination was made of the analyses of the materials charged in the furnace, and it was found that the results agreed with these statements. Samples from 15 casts of metal gave an average phosphorus content of 0.64 per cent., samples taken from Plane 4, 0.32 per cent., and from Plane 5, 0.54 per cent. The results show that half of the phosphorus had entered the metal or was very intimately in contact with the metal before it had reached Plane 4, and approximately 84 per cent. had entered the metal by the time it had reached Plane 5. The ease with which the metal takes up the phosphorus is readily shown by the results. As phosphorus is not completely reduced until a temperature of 1,150 deg. C. is attained, it is quite possible that it was not in phosphide form until a point well down in the bosh was reached.

Carbon.

For a long time it has been known that iron will take up various elements when heated in their

presence, and carbon is probably absorbed most readily. These experiments show that the order in which iron absorbs such elements during the blast-furnace process is as follows:—Carbon, sulphur, phosphorus, manganese, and silicon. The analyses of metal samples indicate that the iron has readily absorbed a large amount of carbon by the time it reaches Plane 4 and that the carbon in the metal from the casts contained an average of 3.39 per cent. At Plane 4 the metal contained 1,29 per cent., and at Plane 5, 3.19 per cent., while four samples from the tuyère plane gave 3.68 per cent. More than one-third of the carbon has been taken up by the metal by the time it reaches Plane 4; the remainder is absorbed in the bosh of the furnace before reaching the tuyère level.

Sulphur.

Analyses of the metal samples taken at Plane 4 show that the metal has taken up 0.070 per cent. of sulphur, more than the tolerant amount. It has been increased to twice the tolerant limit by the time the metal has reached the elevation of Plane 5, 27 ins. above the tuyère level. Desulphurisation has taken place between this level and the tuyère level, where the sulphur content had been reduced to 0.072 per cent. The ease with which the metal takes up sulphur (above Plane 4) in the sponge-iron zone is readily shown in the analyses. The metal evidently continues to take up sulphur until it is well down into the bosh of the furnace, and desulphurisation therefore takes place between a point below Plane 5 and the crucible.

Summary and Conclusions.

(1) Results of sampling stock and gas in the upper part of the blast-furnace stack show that 80 to 85 per cent. of the iron in the burden has been reduced to the metallic form by the time it has reached a point 19¼ ft. above the tuyère level. (2) It is shown that metal, in the form of sponge iron, has taken up, or is in intimate contact with, considerable quantities of carbon, sulphur, phosphorus, manganese, and silicon by the time it has reached Plane 4, which is 19¼ ft. above the tuyère level and 8 ft. above the bosh level. (3) About 87 per cent. of the silicon entering the metal is taken up while the metal is in the bosh above Plane 5, and the remaining 12 per cent. is taken up between Plane 5 and the crucible, 27 in. above the centre line of the tuyères and the crucible. (4) It is shown that the silica in the coke ash has little effect on the amount of silicon in the metal, because the metal has obtained most of its silicon before it reaches the tuyère level. (5) Approximately one-third of the manganese enters the metal or is very intimately associated with it above Plane 4. The manganese content of 15 casts was 0.53 per cent.; metal samples from Planes 4 and 5 contained 0.22 and 1.10 per cent. respectively. Between Planes 4 and 5 the metal takes up considerable manganese, part of which is probably oxidised later in the tuyère zone. (6) All of the phosphorus has entered the metal by the time the metal has reached Plane 5. Approximately one-half of the phosphorus has entered or become intimately combined with the metal at Plane 4. (7) More than one-third of the carbon has been taken up by the metal by the time it reaches Plane 4; the remainder is taken up while the metal is in the bosh of the furnace and before it reaches the level of the tuyères. (8) The tolerant limit on sulphur is 0.05 per cent. At Planes 4, 5, and 6, the metal contained approximately 140, 360, and 140 per cent., respectively, of the tolerant limit. At Plane 4 the metal had taken up 3.33 per cent. of the sulphur which had been charged into the furnace, while at Plane 5 the metal had taken up 12.0 per cent. of the available sulphur. The results show the ease with which the metal has taken up sulphur in the upper part of the furnace; they also readily show that the metal continues to take up sulphur while it is in the bosh of the furnace, probably due to the fact that part of the metal is not covered by slag, and therefore subject to contamination with sulphur produced from combustion of coke at the tuyère level.

(9) Determination of forms of sulphur in coke samples at Plane 4 shows that approximately 25 per cent. of the sulphur has been removed from the coke by the time that it reaches this plane, and that the sulphur which has been removed is that which existed in the coke as ferrous sulphide and free sulphur. About half of the ferrous sulphide and free sulphur has been removed at Plane 4. (10) Analyses of samples of limestone taken from Plane 4 show that the lime has taken up 0.77 per cent. sulphur, which is approximately 26 per cent. of the available sulphur originally charged. Coke at this point has lost 25 per cent. of its sulphur and the metal has taken up 3.33 per cent. of the available sulphur. Preferential absorption of sulphur by lime in the upper part of the furnace is demonstrated by these results.

Dutch Foundrymen to Meet in Aachen.

The Coöperatieve Vereeniging Van Nederlandsche Ijzergieterijen G.A. ("Covny") of Amsterdam, have extended a cordial invitation to members of the Institute of British Foundrymen to participate in their summer meeting to be held in Aix-la-Chapelle, Friday and Saturday, June 24 and 25 next. The programme is as follows:—

FRIDAY.

4.30. Meeting in Hotel "Kaiserbad," Büchelstrasse 36, Aachen: Welcome to guests and members.

5.30-6.30. Lecture with lantern-slides by Prof. Dr. Ing. E. Piwowarsky: "Foundry Plant installed at the Aachen Technical High School with special reference to Handling Problems."

7.30. Dinner offered by "Covny" to the guests and members.

SATURDAY.

9.30. Visit to the "Technische Hochschule," Aachen. Lecture of Dipl. Ing. Nipper: "Recent Scientific Methods of Testing Moulding Sand," followed by a tour through Aix-la-Chapelle.

12.30. Lunch offered by the "Verein Deutscher Eisengiessereien-Düsseldorf" (German Foundry Owners' Federation).

Any member who can participate should communicate immediately with Mr. Tom Makemson, St. John Street Chambers, Deansgate, Manchester.

Notes from France.

Paris Congress.

The annual Congress of the Association Technique de Fonderie is to be held in Paris in September, and with it will be associated an exhibition of foundry plant and materials. It is to be of an international character, but without American participation.

The following Papers are expected to be presented:—

"Influence of Adding Steel Scrap to Blast-Furnace Charges on the Quality of the Resulting Pig-iron," by Jesse L. Jones (American Westinghouse Electric & Manufacturing Company).

"Tests and Properties of Foundry Sands," by G. Sirovich (Professor of Metallurgy at the Rome School of Engineering).

"A Contribution to the Study of Testing Cast Iron," by Fr. Pishek (Professor at the Brno Polytechnic School).

"Rapid Methods of Analysis," by M. Arzens (International Harvester Company, Croix).

"Breaking-up Heavy Scrap," by M. Gautard (Foundry Manager, Nord-Paris).

"Simple and Rapid Methods for the Control of the Mechanical Properties of Grey Iron Castings," by M. Girardet (Foundry Owner, St. Die).

"Tests of the Inherent Properties of Foundry Pig-iron with Special Reference to High Tensile Iron," by M. Levi (Foundry Manager, Saint Nicholas, Revin).

"Costing and Systematic Working Conditions," by M. Toucheport (Foundry Manager, Dax).

In addition, Mr. J. Goodwin, of Sheepbridge, will present a Paper on behalf of the Institute of British Foundrymen.

MESSRS. AUTOMATIC AND ELECTRIC FURNACES, LIMITED, of Elecfurn Works, 173-175, Farringdon Road, London, E.C.1, have entered into an arrangement with Messrs. G. Blundell & Company, Limited, of Yokohama, for the sale of their Wild-Barfield Electric Furnaces in Japan.

Centrifugal Tube Casting in Hot Moulds.*

By Leon Cammen, New York City.

The use of hot moulds in centrifugal tube casting is a matter of necessity, not of choice. Where the metal is of such a character that it can be superheated without injury, and where the weight of the casting is large, all that is necessary is to maintain the mould at a temperature (approximately 175 deg. C.) at which no deposits of moisture can form thereon. Where, however, the amount of metal cast is small (*e.g.*, in tubes of small diameter, 3.5 in. inside dia. and 4.25 in. outside dia. for blanks used in making hollow billets for drawing small tubes), and the length of the casting considerable (*e.g.*, 60 to 90 in.), metal delivered to the mould from one end (there being no room to use a long spout) simply will not flow in a mould that is merely warm.

The writer, in his work, encountered many instances where, through some trouble in handling the hot mould, the latter was colder than it should have been at the time when the metal was teemed. The invariable result was that the tube cast was too short as it did not fill the mould from end to end.

Except from the patent point of view, it does not matter how the mould is heated. In the Stokes and Hurst-Ball methods (used only with cast iron) the moulds are kept hot by making one casting after another at such a rate that the mould is maintained at the desired temperature. This is, of course, the ideal method where it can be used, as it eliminates the external heating of the mould and the rather bothersome handling of the big hot mould body between furnace and casting machine. This process is, however, applicable only to cast iron and only to the castings of tubes which are either of very large diameters or compensate for the smaller diameter by being short. This is due to the fact that where long tubes are cast of small diameter the contraction on cooling is so small that it becomes necessary to let the casting cool quite materially before the necessary force can be applied to effect the stripping. Where this is done, obviously, the mould will become too cold to handle the next casting, and re-heating by external means other than the metal of the casting becomes necessary.

There is another feature, applying particularly to steel and special ferrous alloys of low-carbon content, which also contributes to the necessity for using a very hot mould in centrifugal tube casting (in this connection attention must be called to the fact that the present Paper deals exclusively with *tube* casting, as conditions are entirely different in the newly developed art of centrifugal *bar* casting). Assume that one is casting a steel tube, to be used as a hollow blank for a seamless tube mill, 8 ft. long, 10 in. outside dia. and 7.5 in. inside dia. The weight of metal in such a tube is so large that, with a spout extending into the mould for a distance of, say, 4 ft., there is no trouble to deliver metal in such a manner that a tube of uniform thickness from end to end will be formed even when the temperature of the mould is only 175 deg. C. This does not mean, however, that the tube will be good. As the first metal is delivered against the fairly cold wall of the mould, it forms a thin tubular shell which immediately contracts on cooling, with the result that the cast tube lies loose in the mould. This condition is aggravated still more by the fact that the mould, heated by the contact with the very hot metal, expands. The result of the combination of these two conditions is that the cast tube, while subject to centrifugal stresses in the process of its formation, receives no support from the mould. The centrifugal stresses in this case are fairly large, 75 to 100 lbs., per pound of metal cast, while the mechanical strength of the shell of a centrifugally cast tube, with molten metal all the time coming on top of it, is naturally low, and cracking of the cast tube results.

The above explains why tubes cast in cold moulds as a rule crack longitudnally and not radially. The centrifugal stresses in a tube in the process of being cast are essentially the same as those produced by water pressure in a cylinder, and it is common knowledge that that is why cylindrical boilers are usually single riveted in the circumferential seams and double or triple riveted in the longitudinal seams.

This cracking does not occur in casting in a highly heated mould, first because the casting does not contract away from the mould until after the spinning has ceased, and second, because the mould itself is so hot that contact with the cast tube does not produce expansion to any material extent.

Materials for Heated Moulds.

The securing of materials for heated moulds in centrifugal tube casting is not an easy matter, because such moulds must satisfy several requirements. In the first place, the mould must not scale and waste away because of the constant application of heating. Next, the mould must retain sufficient mechanical strength at temperatures of the order of 705 to 870 deg. C., at which temperatures the strength of cast iron is negligible. Not only must the mould material retain its mechanical strength, but it must also retain its hardness, as otherwise the rather rough handling between the furnace and casting machine would throw the mould all out of shape. Only such alloys as ni-chrome and the high chromium-iron alloys, such as Becket metal, can satisfy this condition. These metals retain practically their full hardness up to a certain temperature limit, which varies from 1,090 to 1,230 deg. C., depending on their composition, and then somewhat suddenly completely collapse. Next, the coefficient of contraction of the mould material must be not higher, but if possible lower than that of the cast tube. In cold mould centrifugal tube casting, the cast tube contracts while the mould is being warmed and expands, both actions helping to free the cast tube from the mould and facilitating stripping. In hot mould casting there is no expansion of the mould through heating, and mould and casting go through the same temperature reaction. If then the mould on cooling should contract faster than the casting, there will be an obvious danger of gripping of the cast tube by the mould, which would make stripping the tube impossible. Ni-chrome, for example, has a higher coefficient of contraction than steel, which makes the use of ni-chrome moulds, notwithstanding their excellent thermal properties, undesirable. The rate of contraction of Becket metal is approximately the same as that of steel.

There is one more requirement which none of the materials previously enumerated satisfies, and this is, ability to withstand with impunity the terrific temperature of molten steel. To be capable of this, the mould material should be such as to melt at a temperature far above that of steel, and there is none that could be used for mould-making that would do this.

Experiment to Develop Mould Material.

In an effort to obtain such a material a series of tests have been undertaken since 1921. The extremely high melting point of tungsten naturally directed attention to this wonderful material, and after a certain amount of rather strenuous work, the author has succeeded in finding a method for melting it without oxidation or absorption of hydrogen. He has never succeeded, however, in melting more than 4 lb. at a time, and while little ingots have been obtained he has come to the conclusion that it would not be possible to melt by this process the thousands of pounds necessary to make commercial moulds for tube casting.

We next tried a process somewhat similar to calorising as developed by engineers of the (American) General Electric Company. There was no special trouble in securing some penetration of tungsten into the body of steel when the latter was properly selected as to analysis, but, while certain otherwise interesting properties were imparted to steel so treated, the melting point of

* A Paper read before the American Foundrymen's Association. The author is Associate Editor, American Society of Mechanical Engineers.

the metal was not affected to any appreciable extent. The author then proceeded to develop a method for creating on the inside of a low-carbon steel or wrought iron a lining $\frac{1}{8}$ to $\frac{1}{4}$ in. thick, consisting essentially of tungsten, chromium and some iron. With the somewhat limited facilities employed thus far, the author has not been able to line tubes larger than 6 in. inside dia. or longer than 36 in., but while the manufacturing details remain to be worked out, the problem may be considered as having been solved in its essential features.

Protecting Mould Surface from Solvent Action of Hot Steel.

All hot moulds used in centrifugal tube casting have to be protected from the solvent action of molten steel. This may be done in several ways. Where an extremely low carbon steel is used a layer of oxide on the internal surface of the mould will be satisfactory. It is not sufficient, however, where the carbon content exceeds, say, 0.08 per cent., as there the oxide on the surface of the mould is reduced by the carbon in the steel, gas is formed, and as it has no other way to escape except through the metal, blowholes result. These blowholes, by the way, have a peculiar shape, somewhat like pears, with the thin end towards the mould.

The writer has tried several combinations including clay, kaolin, etc., but ultimately came to the conclusion that the best material is castor oil, alone or with enough lampblack to bring it to a molasses-like condition. This should, of course, be applied before the mould is heated. In this connection might be mentioned a curious thing about castor oil which the writer had occasion to note in casting duralumin tubes some years ago. The moulds were heated to about 650 deg. C., after having a coating of castor oil applied to them. When the cast tubes were withdrawn they had an outside surface as smooth as glass and *were actually wet with oil.*

Temperature of Hot Moulds.

There is no general formula for determining the temperature of hot moulds in centrifugal casting. It depends on the freezing characteristics of the metal cast, thickness of wall of the cast tube, length of casting, and several other features. As a general rule, it may be stated that it is advisable to teem the metal as cold as possible, even when this means heating the mould to an especially high temperature. When the metal to be cast is "superheated" an enormous quantity of heat is released at the time of freezing of the metal, and there is serious danger of the mould burning out. There have been several instances of this in casting stellite which melts at a temperature much lower than steel, but is cast in a superheated condition. In casting monel metal, however, melting some 220 deg. C. higher, there never was a case of a mould burning through.

There is one thing that the writer desires to emphasise in concluding his Paper, and that is, that centrifugal casting in hot moulds has a certain field in which it *has to be* used simply because there is not known any other way to accomplish the same results. It is a new art, less than five years old, and there are still so many problems in it to be solved that it is therefore not to be undertaken by amateurs. In fact, a very high grade of engineering and metallurgical ability is required to carry it on successfully. Some very interesting results have been obtained by centrifugally casting tubes in hot moulds; the art is in strong hands, and many of the difficulties in the way have already been overcome, while earnest work is being done to eliminate such other difficulties as still remain.

The Grangesberg Company report shipments of iron ore totalling 740,000 metric tons in May, as compared with 736,000 last April.

Mr. Frank Dawson, who was recently associated as engineer with Messrs. J. Rolland & Company (agents for A. G. Krupp, of Essen), has joined the staff of Messrs. John A. Smeeton, Limited, of 15, Victoria Street, London, S.W.1. He will be attached to the department handling the manufactures of the Demag, A.G., of Duisburg.

Discussion on Mr. Castle's Paper on "Science in the Foundry."

This Paper appeared in our issue of March 31.

Mr. Russell said the author had omitted to give the composition of the low-carbon iron mentioned. The process for the desulphurisation of cast iron could not be recommended unless the cupola had a receiver, and thus would be very difficult to adopt to any ordinary cupola. Could the author suggest a remedy when a receiver was not available. Referring to the cost of applying scientific control to the foundry, the author had recommended a chemical analysis of every truck of pig-iron, coke, etc.; but from the financial point of view it was impossible. If a foundry could rely upon a few brands of iron, and was satisfied that the suppliers were anxious to keep their product uniform, he did not think an ordinary foundry was going to suffer by not adopting wholeheartedly a complete scientific control. He was glad to hear that the question of porosity of sand was being cleared up, but the authorities on the subject differed. Had the author a satisfactory test for porosity? If so, he would be glad to hear it. The bucket test for oil-sand cores referred to by the author did not appeal to him as a very scientific procedure. Possibly the author would enlarge on it. With regard to coke: the author had stated that sulphur should not be more than 0.800 per cent. and mineral matter from 7 to 10 per cent. He would like to know if coke could be bought to this analysis.

Mr. Castle, in reply, gave the composition of low-carbon cast iron as: T.C. 2.80, Gr. 2.05 to 1.95, C.C. 0.75 to 0.85, Si. 1.60 to 1.80, S. 0.06, P. 0.30 and Mn. 0.60 per cent.

The method to be adopted for desulphurisation of iron when a receiver is not available would be to use a tea-pot ladle and to add to it the necessary desulphurising bricks or powders, just before the iron is tapped from the cupola, then allow a little time for the material to do its work. This method is effective and simple.

Scientific control in the foundry can be obtained in a very effective way and giving great help to the foundry at very little cost, in fact, the cost per year would work out at no more than at an extra cost of a labourer in the foundry being engaged. Of course, this method means the employment of a suitable outside laboratory. A method is shortly to be recommended for testing the porosity of sand, being the outcome of a research made at the University of Cornell in U.S.A.

The bucket test for sand testing was not a scientific measure, but for all that it was useful, and acted as a comparative test. The method could be used by any foundryman. One large foundry in the north employed this method every day and much useful data had been obtained.

The coke analysis specification mentioned was being guaranteed at least four firms in Great Britain, and from experience of undertaking analysis and testing, he could vouch for this.

Mr. Pemberton said he did not agree with the author's advocacy of taking a chemical analysis from every truck. He was very pleased to note the author's description of one of the slides as a "pearlitic structure" and not as a "pearlitic iron." "Pearlitic iron" was a misnomer. He congratulated the author on the slides shown. He would like to hear something about the machining qualities of low-carbon cast iron.

Mr. Castle said that the nature of the scientific control depended on the type of the castings to be made, and it was a matter for the judgment of the foundry officials.

The machining properties of low-carbon cast iron were satisfactory. In some cases, however, it is slightly more difficult than ordinary iron, but in many cases the tools used in the machine shops were not prepared to perfection. In fact, this often happens on ordinary castings and blame is laid upon the foundry, when, as a matter of fact, the trouble lies in the machine shop.

Mr. Stevenson said he would be glad to hear the author's views on the damping of coke before charging.

The author thought that the damping of coke before charging had proved satisfactory, and he advocated it when the coke was not of satisfactory quality.

Laboratories and Works of Beecroft & Partners, Limited.

So far as most of our foundries, both ferrous and non-ferrous, are concerned, we have, happily, long since passed the stage of the put-and-take system of working, in which chance naturally played an important part and the uniformity of product from a number of casts, presumably made from the same mixture, was the exception rather than the rule.

To-day, if the foundryman chooses to avail himself of the facilities available for chemical, microscopical and physical control of his raw materials, as also of the intermediate operations, the manufacture of a uniform production, whether in ferrous or non-ferrous metals, is, one might almost say, a scientific certainty.

Economic considerations oblige us to buy at the cheapest markets, and governed by such conditions, scientific control must be regarded as essential if a high standard of production is to be attained and maintained.

It is not only from a quality point of view that we must seek scientific assistance, but it is equally essential from the financial side; in this connection the actual cost of such control would often be more than covered by the reduction in scrap alone, apart from the savings which would undoubtedly be effected in fuel and refractories.

A few years ago the scientific control of foundry operations was only possible with the largest concerns, and even here there were strict limitations. It is not commercially possible to maintain a large staff of qualified metallurgical chemists, thus for the most part the work is in the hands of one man, who, having to take sole control of the routine portion of the work, had little or no time available for the conduct of research work, without which it is impossible for any manufacturing industry to be kept in line with modern developments. In no industry has science wrought such revolutionary changes and in so short a period as that of founding, and it would seem that in the near future only such foundries which are controlled on the most modern lines can hope to be commercially successful.

Obviously, as already pointed out, it is not commercially possible to provide the necessary staff within the foundry to conduct the various analyses, chemical and physical tests, combined with experimental research, which are each inseparable components to the scientific control of the foundry.

There is, however, no longer existing any excuse for the absence of scientific control, since there are available independent laboratories staffed by highly trained chemists and metallurgists whose services are not only available, but are financially possible to even the smallest foundry.

One often hears the remark that laboratory propositions are not practical in the foundry under ordinary working conditions, and it must be acknowledged that the contention often contains an element of truth. The function of the laboratory is to determine certain facts or conditions, it then remains to reduce such facts and conditions to a practical issue within the foundry itself.

FIG. 1.—CARBON TRAIN; MESSRS. BEECROFT & PARTNERS, LIMITED.

Recognising the necessity for close collaboration between the laboratory and the foundry, Messrs. Beecroft & Partners, Limited, have acquired the use of a well-equipped foundry for experimental purposes, and in this foundry they undertake, for the benefit of their clients, the necessary research for arriving at special mixtures, test bars taken from the cast are subject to chemical analysis and physical tests, the data which has been thus obtained on a commercial basis being available within a few days—a practical rather than an academic issue.

The Beecroft & Partners' laboratories and works are situate in St. Peter's Close, Sheffield. The laboratories comprise a balance and combustion room, which is equipped with a gas-fired 4-tube carbon combustion furnace fitted with a Huxley type of special muffle. Reference may be made to the carbon train of this furnace, as into this important modifications have been introduced by the laboratory staff.

The oxygen is run through a 50 per cent. caustic soda solution, and in series through a lime tower which is charged with lime through a 10-mesh. The pure oxygen is then run through

the tubes at high temperature, the steel for testing is charged into boats of a special material known as "Carbest." It is claimed that whilst these boats are much cheaper than porcelain, they are equally as good and can be used three times. The charged boat is sprinkled with lead chromate to assist combustion.

The carbon is, as usual, burnt to CO_2 with oxygen. The outlet from the tubes is packed with asbestos wool to eliminate the possibility of CO_2 passing over. From the trap the gases pass in series through two Carbest bulbs containing from 15 to 20 c.c. of mixture of sulphuric and chromic acids, thence through a Carbest bulb containing 10 c.c. pure sulphuric acid. It will be noted that there is no spraying, the gas passing direct from the sulphuric acid to the calcium chloride and thence to the Carbest absorption bulbs. This Carbest is a special production of Beecroft & Partners, and by its use accurate estimates of carbon in iron and steel can be obtained in 8 minutes by direct combustion, the furnace temperature required being 950 deg. C. Fifty grammes of this material will absorb 7 grammes of CO_2, the colour changing as absorption progresses.

The Carbest bulb is another speciality, being robust and very light, weighing when fully charged with carbest only 100 grammes.

It is interesting to note that an order for 8,000 samples of material for carbon tests by combustion has just been completed.

The general laboratory adjoins; the equipment includes the usual fume chamber, gas-fired furnaces and other apparatus, which, however, does not call for special mention. In the laboratory an average of 100 complete analyses are made per week, dealing approximately with 500 single elements. The laboratory was in point of fact taxed beyond its capacity, and in order to afford the necessary relief, space for extensions not being available at the St. Peter's Close Works, premises were acquired in Hartshead—which is conveniently close—where a laboratory has been laid out to deal more particularly with sulphur and phosphorus, non-ferrous metals and special steels. There is the usual fume chamber and small muffle furnaces, etc. In an adjoining room is the micro apparatus with polishing equipment, balances, etc.

Dealing with the works at St. Peter's Close, the machine shop is, of course, specially laid out for the preparation of test pieces, etc. Its equipment includes hack and band saws, drills, planer and grinders; there is also a two-throw hydraulic pump, which is belt driven and delivers into a small accumulator at 1,500 lbs. pressure to furnish power for the testing machines. The test house adjoins the machine shop. The machines comprise a 50-ton Buckton universal machine, Avery impact machine, Izod impact machine, Herbert file testing machine, etc.

The product shop contains two Baker Perkins centrifugal mixing machines, laid off specially for the manufacture of core compounds, which are made in seven distinct grades of standard quality made up of fixed and definite proportions of the various ingredients, the formulæ for which are never changed.

The chemical shop for the manufacture of fluxes, chemical-blackings, etc., is a separate building. Of the various fluxes manufactured by the firm mention may be made of Puric, which is a special cupola flux. This is supplied in brick form. It is claimed that this flux not only gives an active fluid slag, but produces hot fluid iron free from gases and other impurities, reduces the sulphur, improves machining qualities, permits the use of higher scrap mixtures, and at the same time reduces the tendency to draw between unequal sections.

In ordinary cupola practice the charge is 4 lbs. of Puric together with 30-60 lbs. of limestone per ton of metal; the actual quantity would, however, vary somewhat in accordance whether the charge was clean or dirty, as also with the percentage of scrap used.

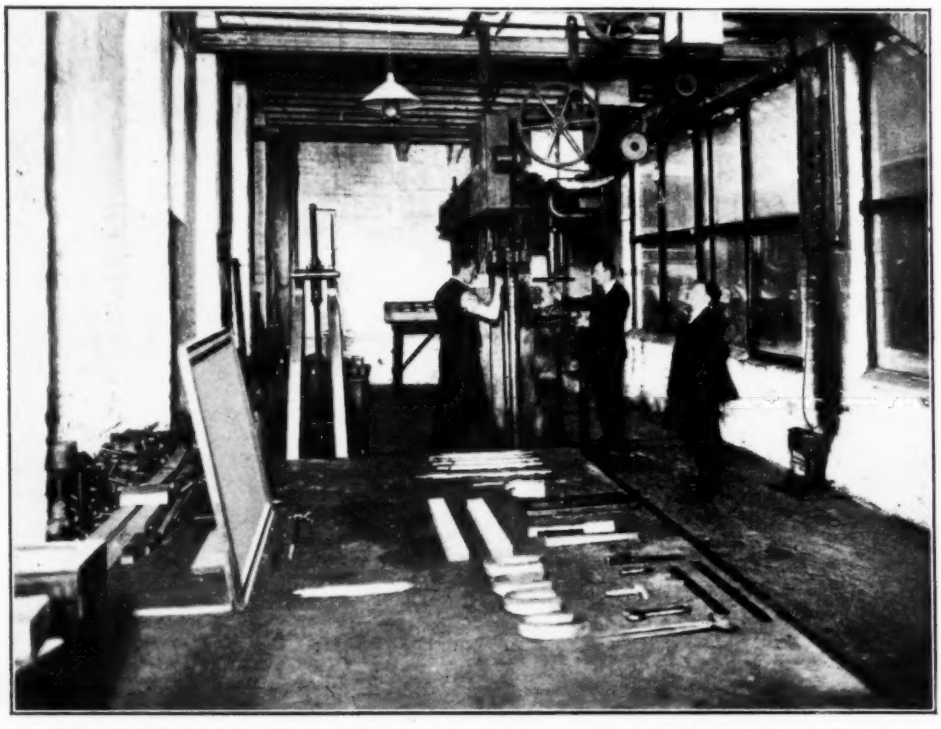


FIG. 2.—MECHANICAL TESTING DEPARTMENT; MESSRS. BEECROFT & PARTNERS, LIMITED.

Professor Turner Testimonial Fund.

Foundrymen both at home and abroad are reminded of the Fund which is being raised in connection with a testimonial to Professor Turner to mark his retirement after a long and distinguished career in the service of metallurgy and foundry work. The Fund will close very shortly, and contributions should be forwarded to the Secretary-Treasurer, Mr. T. Makemson, St. John's Street Chambers, Deansgate, Manchester.

MESSRS. SETTLE, SPEAKMAN & COMPANY, LIMITED, have removed from 90, Lower Thames Street, London, E.C.3, to 90, Cannon Street, London E.C.4. The new telephone No. is City 1426 (3 lines), and the telegraphic address Abbotship, Cannon, London.

Surrey Iron Works.

BY COLONEL H. C. EVANS.

The iron industry of Surrey was, during the Tudor and Stuart periods, one of the most important in the country. Of the period immediately subsequent to the Roman occupation until more than 200 years after the Norman Conquest the history of the iron industry is a blank. It is not possible to claim for Surrey the antiquity that belongs to this industry in Sussex. The earliest date of the first definite mention of Surrey iron works is 1553. On March 24 of that year Lord Abergavenny, by deed of bargain and sale, conveyed to George and Christopher Darrell all his messuages, lands, tenements, and woods, waters and rough grounds called Ewood Park, in the parish of Newdigate, and also "all the buildings, iron works, and offices, set, and being within the same." In 1557 Owen Bray and his wife Ann levied a fine of their manor of Paddynden, or Paddyngton, with its appurtenances, including an iron mill, a pond, 100 acres of wood, etc., at Abinger, Shere, Ockley, Effingham, and Wotton.

The Act of 1 Elizabeth, c. 15, which is entitled, "An acte that timber shall not bee felled to make coles for the making of iron," enacted that thereafter no person should convert to coal, or other fuel for the making of iron any timber tree of oak, beech, or ash, of the breadth of one foot square at the stub, and growing within 14 miles of the sea, or any part of the river Thames. . . . under the penalty of 40s. for every tree, or part of tree, so converted. But there were exceptions from this Act in the favour of Sussex, the Weald of Kent, and the parishes of Charlwood, Newdigate, and Leigh, in the Weald of Surrey. The petition of the inhabitants of Kingston-on-Thames left no doubts about the fears that actuated this policy. On February 5, 1562, they complained that whereas they could formerly buy firewood at 2s. 8d. or 3s. and charcoal at 10s. a load, brought from Dorking, and its neighbourhood, they were now compelled to pay 4s. or 4s. 4d. for the former, and 20s. for the latter. They attributed this rise in price to the iron works set up in the county, and they apprehended that unless speedy remedy be had they were like to have neither wood nor coals. London must have also been affected by these prices for it depended on the Surrey forests for fuel; moreover, timber was in great demand for shipbuilding.

Absence of Waterways Prevented Expansion.

These facts show that about this time the Surrey industry was beginning to assume such proportions as to give rise to the probable exhaustion of the timber supply in the county. The late growth of this industry in this county as compared with its progress in Sussex and Kent was due to the absence of waterways. Both the other counties could send their iron to London by water, but the proverbially bad condition of the roads in the Weald made land transport a matter of difficulty and expense. It is probable that the growing demand for iron for ordnance at this period was the main factor in inducing the Surrey ironmasters to grapple with the difficulty of land transport.

The iron ordnance turned out by the Wealdean works was excellent, and this gave the Government another pretext for interfering. In January, 1573, we find Ralph Hogge, "the Queene's gunstone maker, and gun founder of iron," complaining of the infringement of his patent to export iron ordnance. A note is appended to his petition of all the furnaces which daily cast guns and iron shot. From this it appears that beside Hogge two other founders had long cast, but only for the Tower, while four other founders, including Sir Thomas Gresham, are mentioned, who had only begun to cast within the last five or six years. The yearly output of these furnaces was estimated at above 400 tons.

In reply to his petition a list was made for the Privy Council of all the iron mills and furnaces then existing in the counties of Surrey, Sussex, and Kent. The great spoil, and "consummation" of oaken timber and other woods are again put forward as the primary grounds of legislative interference with these iron works. At the same time the Privy Council was also actuated by its knowledge of the fairly brisk sale of ordnance to foreigners, which resulted in the loss of many British ships at sea, and much merchandise.

Ironfounders had to enter into an agreement not to cast any ordnance without a licence from the Queen, and only those who had been granted a special licence to sell to foreigners were allowed to do so.

Timber Preservation Important Factor.

The Act referred to above for the preservation of timber (1 Eliz., cap. 15) was followed by another, 23 Eliz., cap. 5, entitled, "An Acte touching yron milles neere unto the citie of London, and the Ryver Thames," forbidding the conversion into coal or fuel for the melting of iron any wood or underwood growing within 22 miles of London and its suburbs, or the Thames from Dorchester downwards, and within certain defined limits of Sussex, under the penalty of 40s. for every load of wood so employed. No new iron works were to be erected within 22 miles of London, 14 miles of the Thames, and four of the Downs, under pain of £100. Whether this Act failed to meet the case or not is unknown, but in 27 Eliz., cap 19, we find: "An Acte for the preservacion of tymber in the Wildes of the counties of Sussex, Surrey, and Kent, and for the amendment of the High Waies decayed by carriage to and fro the Iron Milles there." In this Act the prohibition to erect new iron mills, furnaces, fineries, and bloomeries, takes the most important place. The penalty for the erection of every new mill contrary to this Act was raised to £300. As regards the damage to the highways, which was put down to the transport of coals, mine and iron, it was enacted that for every ton of iron, and every six loads of coal, or mine, carried one mile through any of the highways under the North Downs of Surrey and Kent between October 12 and May 1 in every year the occupiers of iron works should carry one load of cinder, gravel, stone, sand, or chalk, for the repair of these roads, or should pay 3s. 6d. a load in lieu.

Government Interference.

By loading the industry with many harassing restrictions the short-sighted Government of that day tried to destroy it; but it flourished none the less for nearly another two centuries. In 1767 occurs the last positive notice of the iron trade in Surrey when a dispute arose between the inhabitants of Guildford and Godalming as to the position of the turnpike on the Portsmouth road. It was stated, amongst other things, that there was a great traffic to and from the forge, or iron works, at Witley and Thursley Heaths, between Milford and Hindhead; on the other hand it was agreed that not more than one carriage a week went with material to the forge.

The gradual decay of the Wealdean iron industry was not due to the exhaustion of the supply of ore, but to the increasing cost of the charcoal fuel, and the substitution of cheaper methods of production, which resulted from the finally successful use of pit coal for smelting. Norden relates that each furnace spent in every 24 hours, two, three, or four loads of charcoal, "which in a yeare amounted to an infinite quantity." A little more than a century later the furnaces in Sussex and Surrey and Kent, together with those in the Forest of Dean, were consuming annually 17,350 tons of timber, or at the rate of over five tons a week for each furnace.

Iron works existed at the following places:—

Ewood, where the works consisted of a furnace, a forge, and a hammer, as well as a great pond.

Shere and Abinger:—This is the second mill in order of date mentioned in Surrey. In the Trinity Term of 1557 Owen Bray and his wife levied a fine of their Manor of Paddington, and the appendages included an iron mill, a pond, 100 acres of wood, and a considerable extent of heath and moorlands in Abinger, Shere, Ockley, Effingham, and Wotton, Haslemere, and Pophall. This dates from 1574, when Lord Montague had a forge and a furnace in Haslemere, and thereabouts also a furnace called Pophall. The 1574 list has "The Ladye Braye, one forge at Cranleye, in the hands of Gardener," and, further, one John Lambert, a

forge at Cranleye. John Lambert and Gardener are identical, for there is a bond taken on February 28 of the same year by John Lambert, alias Gardener, of Cranleye, County Surrey, Yeoman, the signature being merely John Lambard.

There were works also at Copthorne, Lingfield, and Dunsfold. A lawsuit in connection with the last-named in 1583, is interesting in that it gives one an idea of the output of a hammer mill. In three years 234 tons, 3 quarters, 14 pounds of iron sows had been brought to the forge, and if the instructions given had been properly carried out this amount would have been increased by another 14 pounds.

The first mention of Thursley and Witley Heath is found in a deed of December 17, 1617, which, however, recites a previous deed of May 14, 1610, in which the works are described as the "iron forge and iron hammer for iron work then lately erected on or upon Thursley Heath, or Witley Heath, in the parish of Witley, or Thursley."

The chief aim of the ironmasters was to convert the ore into marketable forms, such as bar iron, or pig-iron, so that it could be readily carried over the country, and sold to smiths. The method they adopted was as follows. The fuel was invariably charcoal, and the blast to the furnace was supplied by water power, the pond being dammed to work a wheel, which alternatively opened and compressed a pair of bellows. Another pond worked a wheel which raised and let fall the hammer of the forge. At the forge the metal was reduced from the ore, and cast into sows or pigs. The mine, as the ore was called, was dug from a depth of from four to 40 feet or more. Before it could be put into the furnace the several sorts of it had to be mixed together so as to enable it to melt to better advantage; then alternate layers of ore and charcoal were piled together, and the whole burnt. The effect was to "mollify" the ore, and allow it to be broken into small pieces. These were put into the furnace, which had already been charged with charcoal, and after 12 hours' melting were drawn off in sows or pigs. The average amount of iron made in a period of six days was eight tons. The forge, or hammer had at least two fires: one called the "finery," and the other the "chafery." At the former the sows were converted into blooms or four square masses of about two feet in length, and next into anconies, which were bars three feet in length with rough ends. At the chafery, these rough ends of the anconies were drawn out, and rounded off, the bar being thus brought to its perfected state. One man and a boy at the finery were expected to turn out two tons of iron in a week, while the chafery men should, in the same time, make five or six tons. Twenty-four loads of charcoal were needed to make eight tons of sows in the furnace; three loads of the biggest "coals" went to one ton of iron at the finery, and one load of smaller "coals" would draw out a ton at the chafery.

Scientific Costing.

By J. W. Kearsey.

It is generally recognised that the foundry industry is suffering from the lack of uniform and sound methods of price fixing. This trouble is largely due to misconstruction of costing rather than to its absence. Costing must be scientific rather than academic.

The attention of the foundry management is so confined to technical operation and general administration that insufficient time is available for planning suitable methods of costing and price fixing, and, further, taking full advantage of such benefits. Also in many cases the foundry manager has admittedly neither the knowledge nor the inclination to devote to these problems. Consequently their practice devolves upon the secretary or office manager, whose viewpoint is frequently so divorced from the scientific that the results achieved may be said to be even more prejudicial to the general interests than the complete absence of any form of costing.

The determination of foundry costs can be handled much more satisfactorily by a technical man than by an accountant, provided that he is conversant with the fundamentals of costing and fully understands the general basis on which he must work.

The principle of predetermination of costs must be definitely accepted; costs must be analysed into factors and controlled by standards. Costing and price fixing must be recognised as being governed by the function of scientific estimating rather than by obsolete methods of cost finding. Price must be controlled by what the article should cost and not by what it does cost. Inefficiency of production can never be charged against the buyer.

It is not fully realised that estimates can be determined with such accuracy from cost standards and by means of formulæ that such estimates can be reproduced as costs, provided that a certain standard of production efficiency is maintained.

This scientific estimating must be carried out by a specialist, whose competency and knowledge of foundry work coincides with that of the production engineer in the machine shop, and who, in addition, must be capable of converting his knowledge of production into costs.

This specialist must be fully conversant, in detail, with the various operations and processes of foundry work. By reason of this capability he is able to prepare standard costs for all jobs and lines of production carried out. A careful study of the various methods of production, machinery, *personnel*, etc., must be made as a preliminary, and from these figures various tables of standards can be prepared which will reduce the work of estimating and fixing cost standards for production to a minimum. In this way it is possible for a skilled estimator to predetermine costs for a very large variety of lines of production.

Orthodox Methods Unsuitable.

The orthodox method of cost finding, as practised by accountants, are totally unsuited for use by a practical management. To give the maximum of results costs must be presented in a comparative form, and this necessitates the predetermination of standard costs for use as measures of performance. The management must be shown the percentage of efficiency or inefficiency at which each department is working. Such aims are impossible under normal schemes of costing, which are devoted to cost finding alone.

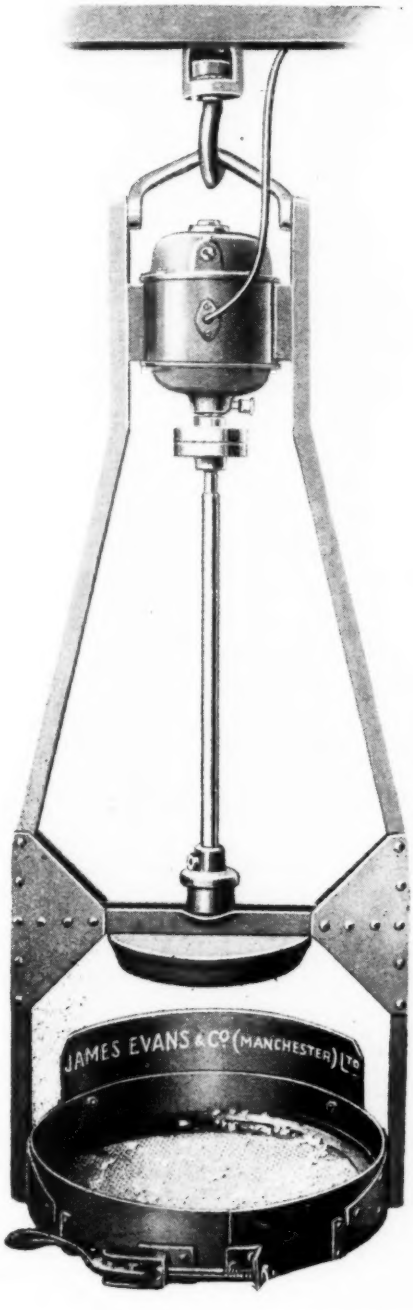
The question of the accuracy of predetermined costs is important. Not only must each factor of cost be visualised and analysed in a practical manner, but allowance must be made for each contingency which may form an item of cost. Certain expenses must be regarded as charges against profits. Defective work is an example of an expense which must be taken into account when preparing cost standards. A certain percentage, varying with the intricacy of the work, must be added to cover rejects and rectification. A comparison of the actual cost of defective work against the standard allowance will obviously be an illuminating aid to both management and board of directors.

The basis of application for profits is probably the most important factor of price fixing. It is just this margin that often determines whether certain work can be obtained or otherwise. The method of application of the profit factor is equally as vital to successful business as the method of apportionment of overhead charges. It may be said that there is no use in calculating fictitious profit ratios if the work is carried out at a net loss. In the case of a loss, however, the factor still holds good for the assessment of the actual loss.

If the profit factor is applied on a weight basis, heavy castings of simple form will be overburdened, and those of light, intricate form will be undercharged. Accordingly, the foundry will be filled with work which does not yield a large tonnage, resulting in low output and small profits.

The converse of this reasoning holds true. The only scientific method of calculating the profit factor is to deduce some formula, which will take into account the amounts of both material and work expended on a job and will load profit in a proportional manner. Other factors may influence the profit factor under certain circumstances, and must be covered accordingly. The method for each foundry must depend upon its exceptional conditions, but the influence of the profit formula must tend to secure the flow of a balanced turnover.

EVANS'S ELECTRIC
GYRATORY FOUNDRY RIDDLE



THE saving accomplished by the use of our Electric Gyratory Riddle pays for the cost of the machine in a few weeks' time.

It will sift more sand with one operator than six men sifting by hand. In addition to this it mixes the sand better, and produces a better grade than hand labour.

The machine is portable and may be moved to any place in a few moments (where a hook for suspension is available and electric current in service) and set in motion instantly.

Motor and working parts are all above the sieve, thus preventing the sand from interfering with the operation of the machine.

Power required, ¼ B.H.P.

JAMES EVANS & CO. (M/c) Ltd.

BRITANNIA WORKS,

BLACKFRIARS, **MANCHESTER.**

The Role of Fluorspar in the Cupola.*

Experiments made by E. Wilke and H. Buchholz showed that fluorspar, when added to molten iron, has a desulphurising effect. The question may arise whether fluorspar, when added to the cupola charge, will show the same effect. Here, in the cupola, the conditions are not favourable for the action of the fluorspar, which is forced to proceed a long way before coming into contact with the molten iron. Thus the chemical composition of the fluorspar may be changed by physical and chemical reactions. In order to examine these conditions, E. Wilke and Th. Klingenstein made the following experiments:—During several days a cupola was worked on with limestone flux, limestone and fluorspar flux, and with a fluorspar flux alone. The sulphur increase of the iron was calculated as the difference of the sulphur content of the tapped iron and that of the charged iron in relation to the sulphur content of the latter.

The experimental results are recorded in Fig. 1.

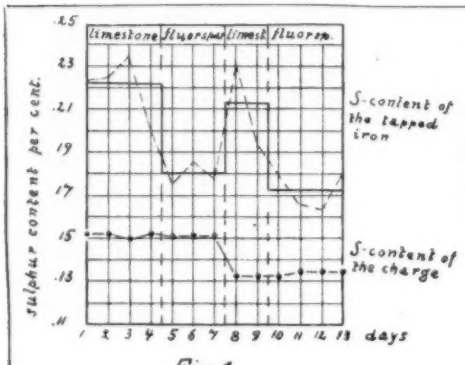


Fig. 1.

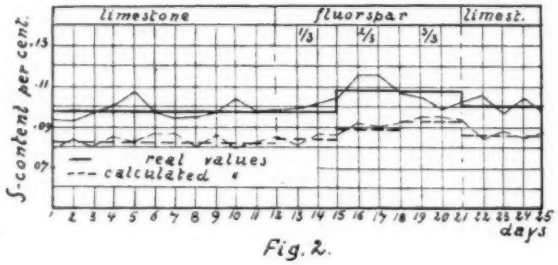


Fig. 2.

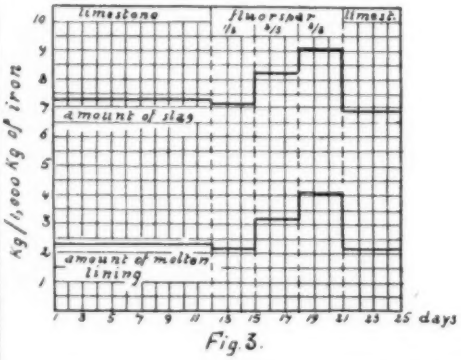


Fig. 3.

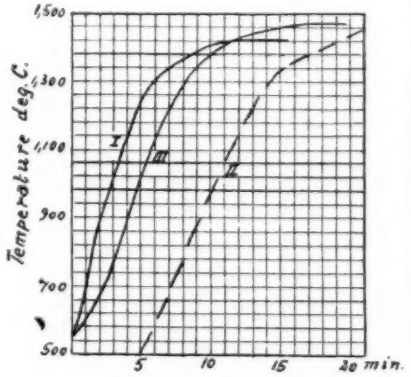


Fig. 4.

From these data it is to be seen that the sulphur increase was 46.5 per cent. and 60.1 per cent. respectively when pure limestone flux was used [days: 1 to 4, and 8 to 9]; it decreased to 19.2 per cent. when limestone and fluorspar flux was used [days: 5 to 7], and was 28.1 per cent. when fluorspar alone was used. From these figures it may be concluded that the conditions prevailing in the cupola do not hinder the desulphurising action of the fluorspar. But the chemical composition of the slag was not a normal one during the days when fluorspar was added, indicating that the cupola did not work normally during this period. As the lime content of the slag had heavily decreased, it was concluded that the lime content of the limestone played a great part. In the above experiments the $CaCO_3$ content of the limestone was 85.0 to 88.0 per cent. Two series of experiments which were carried on with this limestone showed great differences in the lime content of the slag. When a limestone with 98.0 per cent. of $CaCO_3$ was used, the slag showed a normal and equal composition.

Further experiments with fluorspar and limestone (with 98.0 per cent. of $CaCO_3$) gave the following data:—When limestone alone was used, the sulphur increase of the iron was 55.6 per cent.; when both limestone and fluorspar were added, the increase was 63.6 per cent. These figures prove that the desulphurisation of the iron cannot be attributed to the fluorspar. Though the contents of FeO, MnO, and S in the slag did not change when fluorspar was used, the silicon content greatly increased. This fact shows that the fluorspar attacks the lining of the cupola, and it may be concluded that its fluorspar content has greatly diminished when it comes into contact with the molten iron. In the following experiments limestone and fluorspar were added according to Table I:—

TABLE I.

Melting period. Days.	Quantity of		Composition of flux.
	Limestone.	Fluorspar.	
	Kg.	Kg.	
12	20	6	Nominal.
3	13	6	33% of fluorspar.
8	6	12	66 ,, ,,
3	—	18	100 ,, ,,

The quantities were thus calculated that always the same amount of lime was carried to the slag. The compositions both of the materials which were charged and tapped were carefully examined. Moreover, the amount of the molten lining was calculated from the compositions of the tapped iron, of the slag, of the limestone and fluorspar, of the coke, and its ash.

From Fig. 2 it is to be seen that a desulphurisation of the iron by means of the fluorspar did not take place. The lime content of the slag decreased when fluorspar was used, whereas the silicon content increased. The amount of slag per 1,000 kg. of iron corresponded to that of the molten lining, as is seen from Fig. 3. Further experiments showed that when fluorspar is used in the cupola the slag is more viscous than a pure limestone slag, and that, in the former case, no fluorspar can be found in the slag. As the majority of workers are of opinion that a pure limestone slag is more viscous than a pure fluorspar slag, experiments were carried on in this direction with pure materials (silica-clay-limestone and silica-clay-fluorspar respectively), which were fused together in graphite crucibles. The results recorded in Fig. 4 show that the fluorspar slag [curve I] melts at a lower temperature than the limestone slag [curve III], and that the latter cannot become molten [curve II] when

* Extracted from Stahl und Eisen.

ALUMINIUM ALLOYS
B.E.S.A. Standards

(Part of) Aluminium Data Sheet A 121

Specification. No.	Specified Chemical Composition.[1]	Description.	Minimum Tensile Properties.[2] Ultimate tens. str. Tons sq. in.	Per cent. elongation in 2 in.
3L11	*Copper* 6% to 8% ... *Tin* may be used up to 1%	Casting alloy	9	3
2L8	*Copper* 11% to 13% ...	Casting alloy	9	Nil
2L5	*Zinc* 12.5% to 14.5% *Copper* 2.5% to 3.0% ...	Casting alloy	11	3
L24	*Copper* 3.5% to 4.5% *Nickel* 1.8% to 2.3% *Magnesium* 1.2% to 1.7%	"Y" alloy castings	11	Nil

[1] In each of the above alloys the remainder consists of aluminium and normal impurities.
[2] Tensile tests for casting-alloys are made on specimens machined to .564 in. diameter from samples cast 1 in. diameter in a heated iron chill. Tensile tests for sheet are made on stamped specimens with width ½in. to 1½ in., and parallel length 2½ in.

F.T.J. 18/6/27.

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the same amount of energy is used as in the case of the fluorspar slag. From these facts it must be concluded that the fluorspar slag in the state as it is put in the cupola is a secondary product of reaction. Before having attacked the lining, this slag is thinly liquid, and because of its fluorspar content it is able to desulphurise the iron. The experiments in question show that the fluorspar flux has no desulphurising effect upon the molten iron; moreover, it is to be rejected from the metallurgical point of view, as it increases the loss of iron, manganese and silicon, because of the increased amount of slag.

Old Customs in the Brass-Foundry Trade.*

Forty-five years is only a short time in the history of some trades, but, in brass-foundry hsitory it is really a lengthy period, because only 150 years ago it was a new trade in this country. Not that it is the purpose of this article to deal with trade history—that would be a dry subject—but an account of some of the curious customs which have been in vogue during this period in the trade, most of which have ceased to be, and, in fact, are almost forgotten, will be interesting.

Going back then this length of time, it was customary in most brass foundries to find only foot lathes and some very crude hand tools in use. Amazing as it may seem in these days, there was then no "power." The old-time brass dresser had to treadle his lathe, and when the steam engine was introduced a little later he did not at first take any too kindly to it. One reason for this was that he had to pay for the new method. Brass work was produced on the piece-work system. The dressing price was fixed for production by foot-lathe methods. Why should an employer go to the cost of a steam engine to save his men the labour of treadling? It would have been absurd, and so the man had to pay. The deduction from weekly wages was 2½ per cent. to cover "part cost." Talking of some of these old steam engines brings a reminder of some of their extraordinary characteristics. One in particular had the peculiar knack of breaking down whenever an important football match was to be played. The men had to cease work, but only for half a day, as the engine-driver always managed to coax the old engine into resuming work by the following morning. Generally this engine developed the same trait upon the first day of resuming work after a Bank Holiday period, and, curiously enough, there were also some important little weaknesses discovered just before holidays. This necessitated some overtime work being done by the engine-driver to prevent the engine being stopped in working hours, and if the extra money thus acquired by the driver happened to be particularly useful for a holiday it did not make the coincidence less striking.

Another deduction from wages was to cover the cost of gas light. Candles had been in use when prices were fixed, and as the gas cost more than candles, the workman had to pay. In this case, however, the master made a bad bargain. Prior to the advent of the incandescent gas mantle, not much light was obtained from gas. Consequently the gas burner was generally discarded and the gas allowed to flow in great volume straight from the pipe. This gave a better light than the burner, and was also put to another use which inflated the gas bill. It was easy with this flame to boil water and make tea at any hour of the day. Many a man thus developed a strange liking for tea which some critical people have ascribed rather to the pleasure of "doing the gaffer" than the attractions of the beverage.

Whilst on the subject of deduction, it may be mentioned that a further threepence per week was taken from the brass dresser to pay the wages of a "dipper." At first the dresser "dipped" his own work, an earthenware bowl and "ackey" (aqua fortis) being provided. This being found a clumsy and expensive proceeding, a man was engaged solely to do this work of dipping and cleaning of the metal, and what more natural than that the dresser should pay for it? When the dresser did the work himself, by the way, he had a perquisite in the shape of the blue stone or copper sulphate deposited in the bowl, and this, generally saved until the end of the year, and then sold to the suppliers of the aqua fortis, provided a little Christmas pocket money which was *not* spent upon tea.

No doubt there were other similar subscriptions required from wages, and varying in different factories, but all levied with the most laudable desire to keep moving with the times and avoid the necessity for a complicated costing system.

In the matter of tools, too, very simple arrangements were made. Very frequently workmen provided their own files, being allowed to take away and sell the brass filings they made in order to raise the necessary cash. If they wanted a turning tool, a tap, or a die, they would make their own from steel, which was provided. The grindstones in use were very large ones, when new perhaps 4 ft. in diameter by 8 in. or 9 in. thick. These, when badly worn out of truth by constant use, had to be chipped true with the aid of old files, and this required the assembly of all the men using the stone, each one taking a hand in the work of truing and levelling up, the stone itself being revolved by means of a handle, and considerable muscular effort accompanied by some very powerful remarks regarding the quality of the stone.

The ability to improvise tools, or patterns, for any job which came along was highly developed in most of the old-style brassfounders, and was, of course, the outcome of sheer necessity. It led to a wonderful self-reliance and to an all-round knowledge of the use of tools which is necessarily lacking to-day.

* Contributed by Harcourts, Limited, to "Vickers News."

New Companies.

J. R. Ashby, Limited, 69, Moland Street, Birmingham.—Capital £1,000 in £1 shares. To acquire business of manufacturer of brassfoundry, etc., of J. R. Ashby, 69, Moland Street, Birmingham.

Bostock & Bramley, Limited.—Capital £2,000 in £1 shares. Power transmission engineers. Directors: F. J. Bostock, "Gudvangen," Micklefield Lane, Rawden, Yorks.; Beatrice M. Bostock.

A. Harvey & Company (Hove), Limited, 105, Church Road, Hove, Brighton.—Capital £500 in £1 shares. Iron merchants. Directors: Adelaide Harvey and F. Tyson.

S. & F. Hodgetts, Limited, 182, Bishop Street, Birmingham.—Capital £3,000 in £1 shares. Brassfounders. Directors: S. Hodgetts, N. S. Crowley and R. H. Warren.

John Wright & Son (Blackwall), Limited, 26, Naval Row, E.14.—Capital £27,500 in £1 shares. To acquire business of ship-repairers carried on at Blackwall as John Wright & Son. Directors: J. M. Wright and G. F. Wright.

Company Reports.

Cleveland Bridge & Engineering Company, Limited.—Interim dividend, 5 per cent. per annum, tax free.

Guest, Keen & Nettlefolds, Limited.—Final dividend on ordinary shares, 1s. per share, making 10 per cent. per annum, free of tax.

Anderston Foundry Company, Limited.—Net profits, £7,894; brought forward, £2,826; dividend, 6¼ per cent., £9,000; carried forward, £1,720.

Callender's Cable & Construction Company, Limited.—Profit, £356,590; dividend on old and new shares, 15 per cent., of which 5 per cent. already paid.

Chesterfield Tube Company, Limited.—Profit, £9,005; brought in, £15,292; available, £24,299; preference dividend, £5,625; depreciation, £8,000; carry forward, £10,674.

Brooks & Doxey (1920), Limited.—Loss for year, £13,456; depreciation, £24,000; debit balance brought forward, £85,161; carried forward to debit of profit and loss account, £122,617.

Ferodo, Limited.—Net profits, £75,991; brought forward, £16,691; final dividend on ordinary, 15 per cent. (less tax), making 20 per cent. for year; reserve, £15,000; carry forward, £13,761.

Ruston & Hornsby, Limited.—Profit, £89,196; depreciation, £42,443; debenture interest, £25,750; brought forward, £28,307; no dividend on ordinary shares; dividends on both classes of preference shares, £23,500; carried forward, £25,810.

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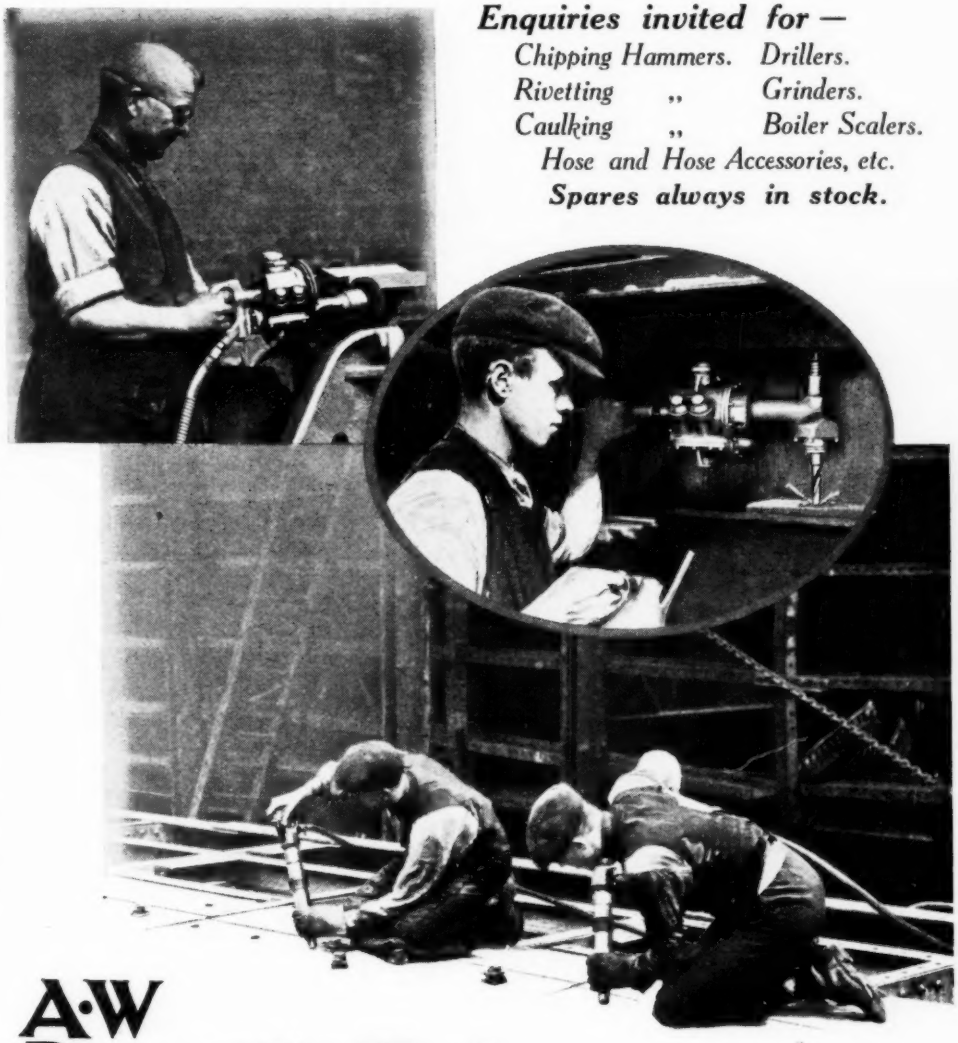

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M.C. 540.

Trade Talk.

THE VULCAN FOUNDRY, LIMITED, have secured a further contract from the London Midland & Scottish Railway Company for 50 locomotives.

PADLEY AND PRICE, LIMITED, Hill Street, Sheffield, are about to transfer their business to Birmingham, in which city they have taken over a works, covering two acres.

THE YUGOSLAV GOVERNMENT has placed an order for 20,000 tons of rails for the Yugoslav railways with the Silesian United Royal and Laura Iron and Steel Works at Kattowitz.

AN ORDER has been placed by the Argentine Government with J. Samuel White & Company, Limited, shipbuilders and engineers, Cowes, Isle of Wight, for the construction of three destroyer flotilla leaders.

BOLCKOW, VAUGHAN & COMPANY, LIMITED, have secured an order for 10,000 tons of 85 lb. rails, and 650 tons of fishplates for the Buenos Aires Great Southern Railway. Delivery is to be made during 1927. Orders for 1,525 tons of tramway rails and 90 tons of fishplates have been received from the Brisbane Tramways, and for 1,000 tons of tramway rails from the Manchester Corporation Tramways.

HEAVY DAMAGE was done by fire to the premises of the Mirrlees Watson Company, engineers, Scotland Street, Glasgow, on June 6. The building principally affected was a wooden pattern shed, 330 ft. long, of which 130 ft. was destroyed, along with the patterns contained in that portion. A quantity of patterns lying in an open yard were also destroyed and some damage was done to a brick-built pattern shop and store where parts of the roof and the third floor were affected.

ON THE OCCASION of his recent visit to Lincoln, the Prince of Wales inspected the Spike Island Works of Ruston & Hornsby, Limited, where he saw various dragline excavators in operation. Two oil-electric dragline excavators are to work on excavation for the Grand Anicut New Canal, Tanjore Delta, and a large dam to be constructed at Metur in the presidency of Madras, India, a district where water is scarce and unsuitable for steam boilers. The canal will be 85½ miles long; will take three years to complete, and is intended to irrigate an immense area of the surrounding country. On arrival at the works the Prince was presented to the following gentlemen:—Ruston & Hornsby, Limited: Col. J. S. Ruston, and Messrs. G. R. Sharpley, F. H. Livens, V. W. Bone, A. R. Bellamy, and H. M. Vales. Robey & Company, Limited: Messrs. W. T. Bell and C. Scorer. Clayton & Shuttleworth, Limited, and Clayton Wagons, Limited: Mr. C. T. Blacklock and Mr. A. Crossley. Babcock & Wilcox, Limited: Mr. T. G. Lewis. Wm. Foster & Company, Limited: Mr. J. Starkey. Harrison & Company, Limited: Mr. J. Butler. Clarke's Crank & Forge Company, Limited: Mr. L. W. Smith. Penney & Porter, Limited: Mr. G. Wright. R. Duckering, Limited: Mr. W. H. Freeman. John Cooke & Sons, Limited: Mr. A. Ball. Firm of M. Pearson: Mr. W. Clapham. Engineering and Allied Employers, Lincoln, Gainsborough, and Newark Association: Mr. J. W. F. Hill (secretary). Lincoln Engineering Society: Mr. E. C. Dunkerton.

THE BRITISH ENGINEERS' ASSOCIATION report this week the successes of British firms in connection with two important overseas contracts which have been obtained. Dorman Long & Company, Limited, have secured the contract for a railway bridge over the River Pungwe in Portuguese East Africa, including 1½ miles of viaduct for the Beira Railway Company. Work will be commenced immediately, and it is anticipated that the contract, amounting to approximately £150,000, will be completed in eighteen months. A British cable-making company—W. T. Henley's Telegraph Works Company, Limited—have obtained the contract in connection with the electrification of the main line of the Great Indian Peninsular Railway of the Indian State Railways for the supply and erection of 269 miles of overhead line on lattice steel towers. The conductors will be of steel-cored aluminium for a working pressure of 110,000 volts. Two parallel double circuit lines will run from Kalyan Power Station to Kalyan, a distance of 2½ miles. From there, two parallel single circuit lines, one on each side of the railway track, will run in a northerly direction to Igatpuri, 50 miles away; and two parallel single circuit lines will run in a southernly direction to Kirkee, 82 miles away. These lines will supply current to the railway from Igatpuri to Poona. The total value of the contract is £300,000. In order to satisfy the growing demand for water caused by the rapid development of the City of Bombay the work of laying pipes from Lake Tansa, more than 55 miles distant, was undertaken, and carried out by Braithwaite & Company (Engineers), Limited. Two parallel lines of pipes, each 72 in. in diameter, have been laid from Tansa to Powai, a distance of 41 miles. At Powai the 72-in. pipes are connected to three pipes, two of which are 57 in. in diameter and one of which is 60 in. in diameter. The two 57-in. pipes are parallel, and continue to Bombay, a further distance of 14 miles, while the 60-in. pipe branches off and meets the old Tansa pipes at Ghatkoper, 3½ miles from Powai. The pipes are formed of steel plate ⅜ in. thick, riveted into lengths of about 57 ft. in the pipe factory, transported by light railway to the field and riveted up to form complete pipe lines by the field gangs. This was located on a jungle site at a small village called Mulund, about 20 miles from Bombay. The plates only were shipped from England.

Contracts Open.

Dewsbury, June 20.—(1b) Valves, penstocks, etc., and rotary distributors; (1c) 3½ tons overhead hand-power traveller and gantry; and (1d) electrically-driven automatically-raked screens and elevators, for Dewsbury Corporation. Mr. H. Dearden, the borough engineer, Town Hall, Dewsbury. (Fee £2 2s. for each contract, returnable.)

Edkou, Egypt, July 25.—Machinery, filters and piping for the water supply works at Edkou, for the Egyptian Ministry of Public Works. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. A.X. 4,764.)

Ely, June 20.—86 9-ft. lengths of 3-in. internal diam. spigot and socket cast-iron water pipes; four 3-in. hydrant tees; three 3-in. spigot and socket cast-iron slow bends; and three double collars for 3-in. pipes. Mr. A. K. Campbell, clerk, Market Square, Ely.

Johannesburg, June 27.—2,000 ½-in. water meters, for the Municipal Council of Johannesburg. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. A.X. 4,753.)

Melton Mowbray, June 22.—4-in. cast-iron pipes and specials, valves and hydrants, for the Urban District Council. Mr. W. H. Jarvis, the surveyor, Corn Exchange, Melton Mowbray.

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—As usually experienced after a holiday break, the Cleveland iron market has been practically idle since Whitsun, and as yet is only slowly recovering from a period of inactivity. There is, however, a limited amount of buying orders in course of negotiation for home consumers, while in the export market some encouraging reports are current of an increasing demand from Continental sources Prices meantime continue unchanged, either f.o.t. or f.o.b., as follow:—No. 1 Cleveland foundry iron, 72s. 6d. per ton; No. 3 Cleveland G.M.B., 70s.; No. 4 foundry, 69s.; No. 4 forge, 68s. 6d.

With heavy stocks on hand, the Tees-side hematite market remains as quiet as recently reported, orders being mostly confined to small parcels, now quoted at about 79s. for East Coast mixed numbers, with 6d. per ton extra for No. 1 quality. On the North-West Coast Bessemer mixed numbers are quoted at £4 8s. per ton delivered at Glasgow, £4 14s. per ton delivered at Sheffield, and £4 15s. to £4 17s. 6d. per ton delivered at Birmingham.

LANCASHIRE.—Buying on foundry account in the local markets for pig-iron is again restricted in volume, the small amount o fbusiness reported being based on the following prices:—Round 80s. per ton, delivered Manchester, is quoted by Staffordshire and Derbyshire makers, with Cleveland No. 3 still on offer at about 83s. and Scottish iron at 98s.

THE MIDLANDS.—Local demand for foundry pig continues disappointing, with but little change in prices, as follow:—Northants No. 3 is quoted at below 67s. 6d. per ton, and Derbyshire at 72s. 6d. per ton would be shaded for a reasonable tonnage, while North Staffordshire No. 3 is offered between 71s. and 72s. 6d. per ton, f.o.t. furnaces.

SCOTLAND.—The Scotch pig-iron market continues featureless. The easing in price continues, and No. 3 foundry is being quoted to-day at 80s. 6d. at furnaces. This is fully 5s. per ton above the lowest touched last year, and consumers are not to be tempted to make contracts.

Metals.

Copper.—Very little increased activity can be noted after the holidays as concerns base metals generally, while the tendency in standard copper has of late inclined to distinctly lower values. Continental demand has remained rather listless, and may not revive much until there is a change for the better in the American market.

Official closing prices of standard copper have been as follow:—

Cash: Thursday, £54 to £54 1s. 3d.; Friday, £53 18s. 9d. to £54; Monday, £54 1s. 3d. to £54 2s. 6d.; Tuesday, £54 10s. to £54 12s. 6d.; Wednesday, £54 to £54 1s. 3d.

Three Months: Thursday, £54 12s. 6d. to £54 13s. 9d.; Friday, £54 11s. 3d. to £54 12s. 6d.; Monday, £54 13s. 9d. to £54 15s.; Tuesday, £55 2s. 6d. to £55 3s. 9d.; Wednesday, £54 12s. 6d. to £54 13s. 9d.

Tin.—The issue of the monthly statistics, contrary to general expectation, has had a strengthening effect in the market for standard tin, the figures showing as follow:—Total visible supply: Month's shipments. 8,646 tons; other afloat, 2,826 tons; total afloat, 11,472 tons; landing, 1,165 tons; in warehouse, 2,018 tons; total stocks, 3,183 tons; total visible supply, 14,655 tons. The position had, however, been discounted in advance, and more active buying for American consumption will probably account for the slight improvement in values.

Official closing prices of standard tin have been as under:—

Cash: Thursday, £293 10s. to £293 15s.; Friday, £294 7s. 6d. to £294 12s. 6d.; Monday, £295 to £295 2s. 6d.; Tuesday, £294 17s. 6d. to £295; Wednesday, £293 to £293 5s.

Three Months: Thursday, £286 10s. to £286 12s. 6d.; Friday, £287 to £287 5s.; Monday, £286 17s. 6d. to £287; Tuesday, £286 12s. 6d. to £286 15s.; Wednesday, £285 2s. 6d. to £285 5s.

Spelter.—Business in ordinary spelter of late has been largely of the speculative order, covering by consumers being very fitful, though at times of fairly large dimensions. There are no concrete signs of a decrease in production, and, in fact, the evidence is rather the other way about, and the outlook is uncertain.

The following are the week's prices:—

Ordinary: Thursday, £28 13s. 9d.; Friday, £28 13s. 9d.; Monday, £28 13s. 9d.; Tuesday, £29 1s. 3d.; Wednesday, £29.

Lead.—Dealings in soft foreign pig during the past week disclosed an unusually sharp recovery, and it would seem as though consumers had been attracted by the comparatively low levels established towards the close of May, when quotations sank to the lowest figure recorded for many years. Since then the price has advanced considerably.

The week's prices are appended:—

Soft foreign (prompt): Thursday, £24 13s. 9d.; Friday, £24 10s.; Monday, £24 10s.; Tuesday, £24 12s. 6d.; Wednesday, £24 8s. 9d.

Production of Steel Ingots and Castings.

The production of steel ingots and castings in May amounted to 882,500 tons, compared with 850,100 tons in April and 45,700 tons in May, 1926.

The following details show the average monthly production in 1913, 1920, 1923 to 1926, and the production in each month in 1927:—Monthly average in 1913, 638,600 tons; 1920, 755,600 tons; 1923, 706,800 tons; 1924, 685,100 tons; 1925, 615,500 tons; 1926, 296,700 tons. Production in 1927, January, 730,700 tons; February, 826,800 tons; March, 949,600 tons; April, 850,100 tons; May, 882,500 tons.

Obituary.

MR. A. MCT. SPENCER died at his home, Whiteley Wood Grange, Sheffield, recently, at the age of 64. As joint managing director of the firm of Walter Spencer & Company, Limited, steel and tool manufacturers, Warren Street, Sheffield, the late Mr. Spencer had many friends in trade and business circles in the Sheffield and Rotherham district, many of whom were present at the funeral on June 1.

J. W. JACKMAN & COMPANY, LIMITED, Vulcan Works, Blackfriars Road, Manchester, announce that their London office has been removed to Abbey House, Westminster, S.W.1.

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